

NANYANG JUNIOR COLLEGE
 JC 2 PRELIMINARY EXAMINATION
 Higher 2

CANDIDATE
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CLASS

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PHYSICS

9749/01

Paper 1 Multiple Choice

20 September 2022

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, class, Centre number and index number in the spaces at the top of this page.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages.

Data

speed of light in free space
 permeability of free space
 permittivity of free space

elementary charge
 the Planck constant
 unified atomic mass constant
 rest mass of electron
 rest mass of proton
 molar gas constant
 the Avogadro constant
 the Boltzmann constant
 gravitational constant
 acceleration of free fall

$$\begin{aligned}
 c &= 3.00 \times 10^8 \text{ m s}^{-1} \\
 \mu_0 &= 4\pi \times 10^{-7} \text{ H m}^{-1} \\
 \epsilon_0 &= 8.85 \times 10^{-12} \text{ F m}^{-1} \\
 &\quad (1 / (36\pi)) \times 10^{-9} \text{ F m}^{-1} \\
 e &= 1.60 \times 10^{-19} \text{ C} \\
 h &= 6.63 \times 10^{-34} \text{ J s} \\
 u &= 1.66 \times 10^{-27} \text{ kg} \\
 m_e &= 9.11 \times 10^{-31} \text{ kg} \\
 m_p &= 1.67 \times 10^{-27} \text{ kg} \\
 R &= 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \\
 N_A &= 6.02 \times 10^{23} \text{ mol}^{-1} \\
 k &= 1.38 \times 10^{-23} \text{ J K}^{-1} \\
 G &= 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \\
 g &= 9.81 \text{ m s}^{-2}
 \end{aligned}$$

Formulae

uniformly accelerated motion

work done on / by a gas
 hydrostatic pressure
 gravitational potential
 temperature

pressure of an ideal gas

mean translational kinetic energy of an ideal molecule

displacement of particle in s.h.m.
 velocity of particle in s.h.m.

electric current
 resistors in series
 resistors in parallel

electric potential

alternating current/voltage

magnetic flux density due to a long straight wire

magnetic flux density due to a flat circular coil

magnetic flux density due to a long solenoid

radioactive decay

decay constant

$$\begin{aligned}
 s &= ut + \frac{1}{2}at^2 \\
 v^2 &= u^2 + 2as \\
 W &= p\Delta V \\
 p &= \rho gh \\
 \phi &= -Gm/r \\
 T / \text{K} &= T / ^\circ\text{C} + 273.15 \\
 p &= \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle \\
 E &= \frac{3}{2}kT \\
 x &= x_0 \sin \omega t \\
 v &= v_0 \cos \omega t \\
 &= \pm \omega \sqrt{x_0^2 - x^2} \\
 I &= Anvq \\
 R &= R_1 + R_2 + \dots \\
 1/R &= 1/R_1 + 1/R_2 + \dots \\
 V &= \frac{Q}{4\pi\epsilon_0 r} \\
 x &= x_0 \sin \omega t \\
 B &= \frac{\mu_0 I}{2\pi d} \\
 B &= \frac{\mu_0 NI}{2r} \\
 B &= \mu_0 nI \\
 x &= x_0 \exp(-\lambda t) \\
 \lambda &= \frac{\ln 2}{t_{\frac{1}{2}}}
 \end{aligned}$$

3

- 1 Which of the following is not a reasonable estimate?
- A Sound of frequency in the order of 10^9 Hz is audible to human beings.
 - B Light of wavelength in the order of 10^{-7} m is visible to human beings.
 - C The volume of an average-sized orange is in the order of 10^{-4} m³.
 - D The speed of beta particles emitted from a nucleus is in the order of 10^7 m s⁻¹.

- 2 The kinetic energy E_k of a rotating solid sphere is given by the following expression

$$E_k = \frac{2\pi^2 I}{T^2}$$

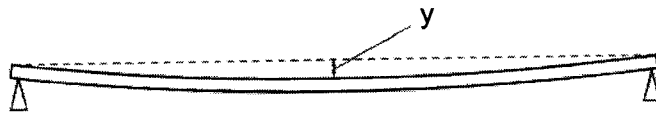
where I is the moment of inertia and T is the period of rotation of the solid sphere.

What is the unit for the moment of inertia I , expressed in SI base units?

- A kg m² s⁻¹
- B kg m²
- C J s²
- D N m s²

4

- 3 A ruler is supported horizontally by two pivots as shown.



The vertical displacement y at the centre of the ruler can be used to measure the mass loaded on it and is given by the equation

$$y = \frac{kML^3}{wt^3}$$

where

- k is a constant,
- L is the distance between the pivots,
- M is the mass loaded onto the ruler,
- t is the thickness of the ruler and
- w is the width of the ruler.

When a particular M is loaded onto the ruler, the following results are obtained:

$$y = (0.25 \pm 0.01) \text{ mm}$$

$$L = (80.0 \pm 0.2) \text{ cm}$$

$$t = (6.0 \pm 0.1) \text{ mm}$$

$$w = (23.0 \pm 0.5) \text{ mm}$$

Which measurement contributes the most to the uncertainty of M ?

- A** y **B** L **C** t **D** w

- 4 The speed of an aeroplane in still air is 200 km h^{-1} . The wind pushes it from the west at a speed of 85.0 km h^{-1} .

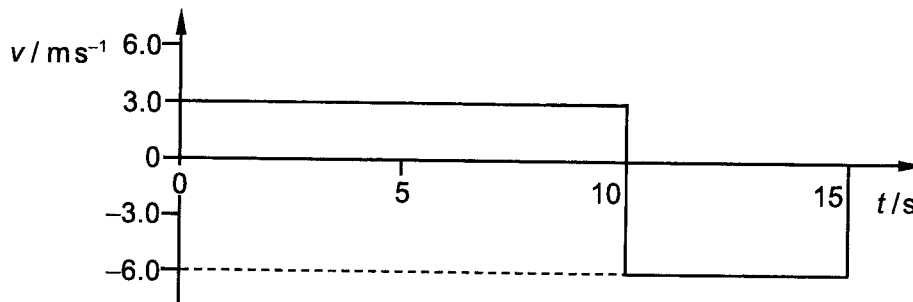
In which direction must the pilot steer in order to fly due north?

- A** 23.0° east of north
- B** 23.0° west of north
- C** 25.2° east of north
- D** 25.2° west of north

5

- 5 A radio-controlled toy car travels along a straight line for a time of 15 s.

The variation with time t of the velocity v of the car is shown below.



What is the average velocity of the toy car for the 15 s journey?

- A -1.5 m s^{-1} B 0.0 m s^{-1} C 4.0 m s^{-1} D 4.5 m s^{-1}
- 6 A tennis ball is thrown horizontally in air from the top of a tall building. The effect of air resistance is not negligible.

Which of the following correctly describes the subsequent change in the horizontal and vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	constant	constant
B	constant	increases at a constant rate
C	decreases to zero	increases at a constant rate
D	decreases to zero	increases to a maximum value

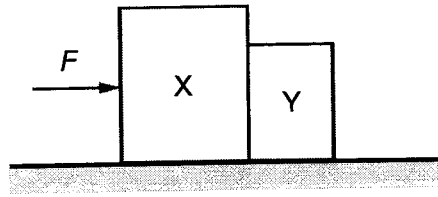
- 7 A rock of mass $2m$ in deep space, initially travelling at velocity v , explodes into two parts of equal mass, one of which becomes stationary immediately after the explosion.

What is the kinetic energy of the moving part after the explosion?

- A $\frac{1}{2}mv^2$ B mv^2 C $\frac{3}{2}mv^2$ D $2mv^2$

6

- 8 A single horizontal force F is applied to a block X which is in contact with a separate block Y, as shown.

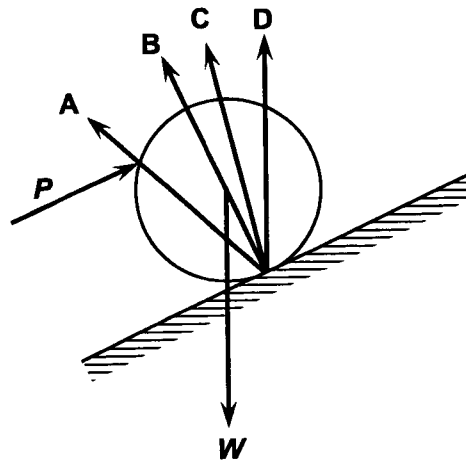


The blocks remain in contact as they accelerate along a horizontal frictionless surface. X has a greater mass than Y.

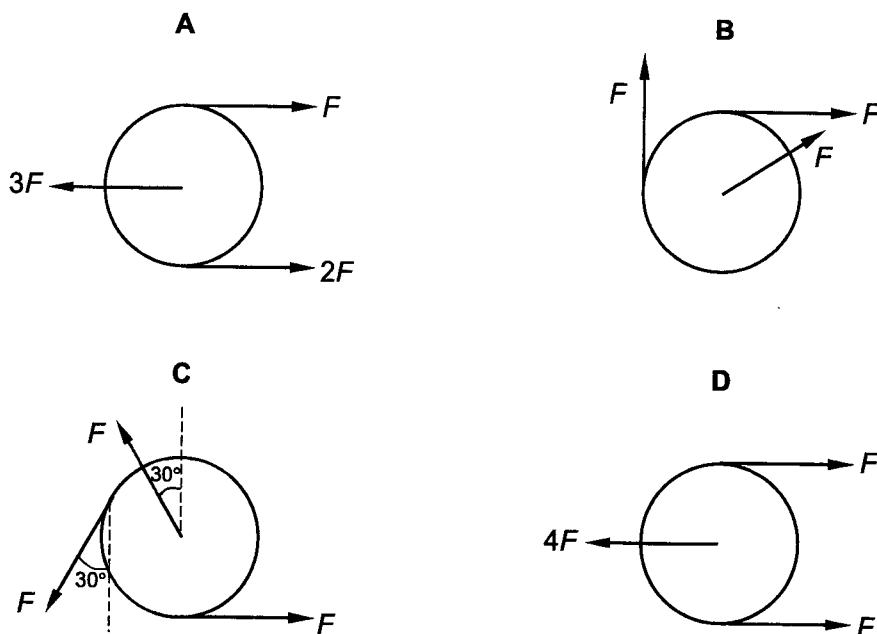
Which statement is correct?

- A The acceleration of X is equal to force F divided by the mass of X.
 - B The force that X exerts on Y is equal to F .
 - C The force that X exerts on Y is less than F .
 - D The force that X exerts on Y is less than the force that Y exerts on X.
- 9 A full barrel of weight W is being rolled up a ramp. The force P is required to hold the barrel at rest on the ramp. Friction between the barrel and the ramp stops the barrel from slipping.

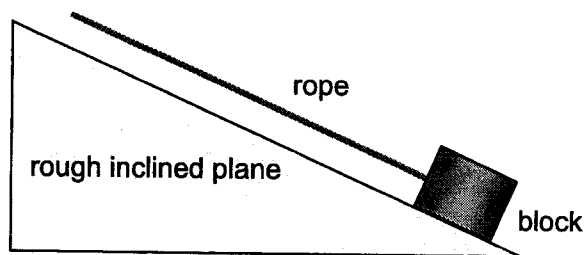
Which arrow shows the resultant force that the ramp exerts on the barrel?



- 10 An isolated disc is subjected to three forces, each given in terms of units of magnitude F .
In which situation will the disc experience both a resultant force and a resultant torque?



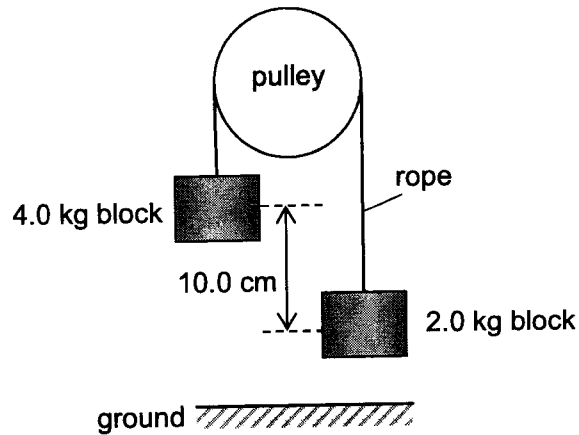
- 11 A block is being pulled up a rough inclined plane using a rope at a constant speed.



Which of the following statements is correct?

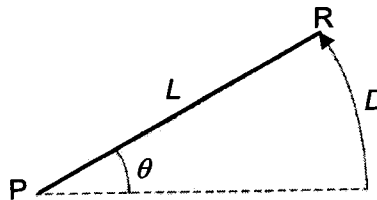
- A The weight of the block does no work because the block is not moving in the direction of its weight.
- B The work done by the force of the rope is equal to the work done against the frictional force from the plane because there is no gain in kinetic energy.
- C The normal reaction force from the plane does positive work because it has an upward component and the block is moving upwards.
- D The negative work done by the weight of the block is equal to the gain in gravitational potential energy of the block.

- 12 The figure below shows a light inextensible rope that passes over a light smooth pulley with two blocks of masses 4.0 kg and 2.0 kg attached to its two ends. The two blocks are initially at rest with the 4.0 kg block 10.0 cm above the 2.0 kg block.



What is the speed of the blocks when they are at the same height above the ground?

- A 0.57 m s^{-1} B 0.81 m s^{-1} C 0.99 m s^{-1} D 1.4 m s^{-1}
- 13 A rod PR of length L is turned about the point P through an angle θ .

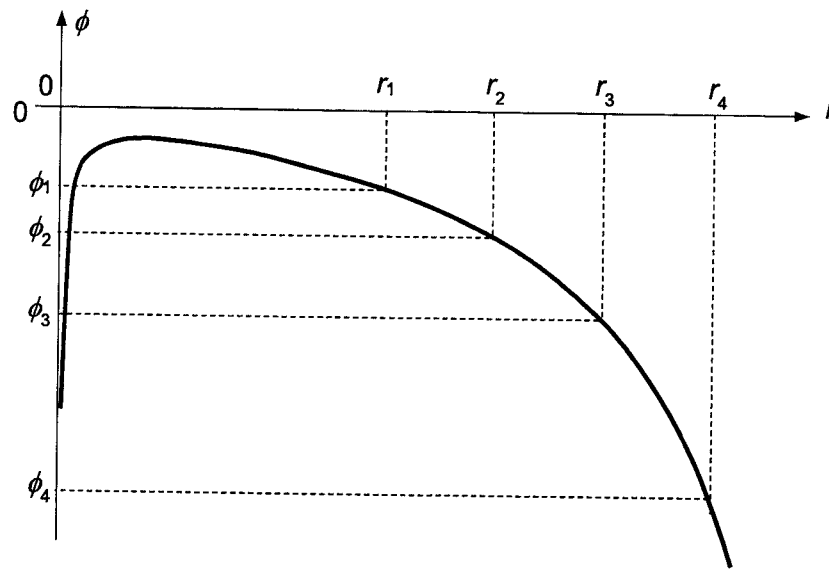


The end R of the rod moves through a distance D . Both D and L are measured in metres.

What is the angle θ , expressed in radians?

- A L/D B D/L C DL D $1/(DL)$

- 14 The gravitational potential ϕ along the line joining the centres of a planet and its moon varies with the distance r from the centre of the moon as shown.



Which of the following expressions gives a value that is closest to that of the gravitational force acting on a 1 kg mass at a distance of r_2 ?

- A $\frac{\phi_1 - \phi_2}{r_2 - r_1}$
- B $-\frac{\phi_2}{r_2}$
- C $\frac{\phi_1 - \phi_3}{r_3 - r_1}$
- D $\frac{\phi_1 - \phi_4}{r_4 - r_1}$

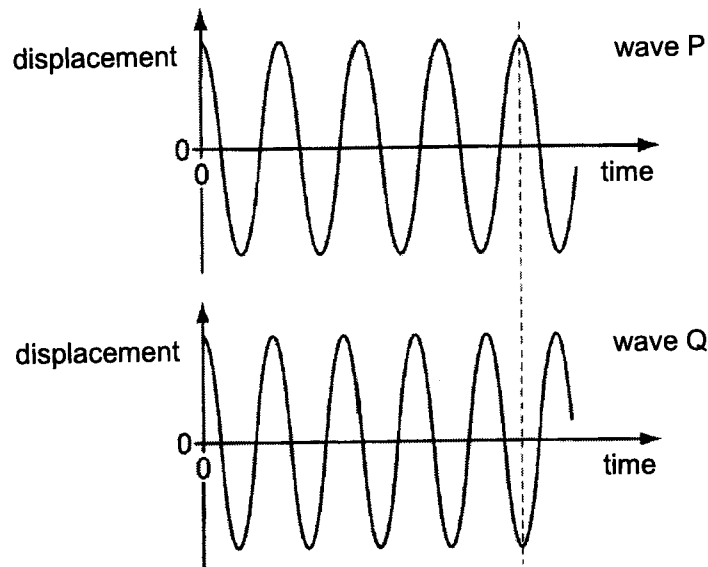
- 15 Earth has a mass M and radius R . X is a point $5R$ from the center of the Earth.

An object of mass m falls freely from rest at X and hits the surface of the Earth.

Which of the following statements is false?

- A The change in gravitational potential is $\frac{4}{5} \frac{GM}{R}$.
- B The work done by the gravitational field is $\frac{4}{5} \frac{GMm}{R}$.
- C The speed of impact is $\sqrt{\frac{8}{5} \frac{GM}{R}}$.
- D The change in the magnitude of gravitational field strength is $\frac{24}{25} \frac{GM}{R^2}$.

- 16 The diagram shows the displacement-time graphs of two sound waves P and Q at a point in space. The graphs have the same scales for the time axes.



The frequency of Q is 125 Hz. The waves are in phase at time = 0.

At what time are the waves next in phase?

- A 32 ms B 36 ms C 64 ms D 72 ms
- 17 Which of the following correctly states the changes, if any, in the potential energy and kinetic energy of the molecules of a solid as it melts?

	potential energy	kinetic energy
A	decreases	increases
B	increases	remains the same
C	remains the same	decreases
D	remains the same	remains the same

- 18 The frequency of a wave is 600 Hz and its speed is 330 m s^{-1} .

What is the phase difference between the oscillation of two points on the wave that are 0.275 m apart?

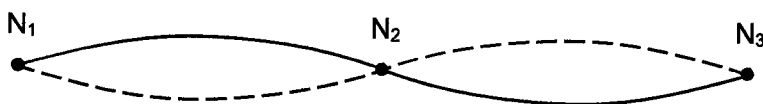
- A 0 B $\frac{\pi}{4}$ rad C $\frac{\pi}{2}$ rad D π rad

- 19 A point source emits 50.0 W of sound energy in all directions. A small microphone of area 0.85 cm^2 detects the sound at 4.0 m from the source.

What is the power received by the microphone?

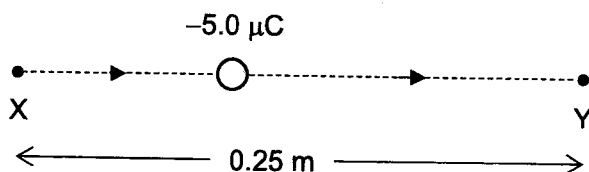
- A $1.6 \times 10^{-5} \text{ W}$
- B $2.1 \times 10^{-5} \text{ W}$
- C $2.1 \times 10^{-1} \text{ W}$
- D $2.5 \times 10^{-1} \text{ W}$

- 20 The diagram shows a standing wave on a string. The standing wave has three nodes N_1 , N_2 and N_3 .



Which statement is correct?

- A All points on the string vibrate in phase.
 - B All points on the string vibrate with the same amplitude.
 - C Points equidistant from N_2 vibrate with the same frequency and in phase.
 - D Points equidistant from N_2 vibrate with the same frequency and the same amplitude.
- 21 A particle of charge $-5.0 \mu\text{C}$ is projected from X towards Y with kinetic energy $250 \mu\text{J}$. When the particle is at Y which is 0.25 m away from X, its kinetic energy decreased to $150 \mu\text{J}$.

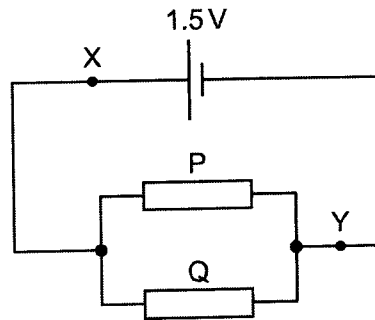


Which of the following statements may not be correct?

- A X is at a higher electric potential than Y.
- B The potential difference between X and Y is 20 V.
- C The electric field between X and Y is of uniform strength 80 N m^{-1} .
- D The electric field between X and Y is directed towards Y.

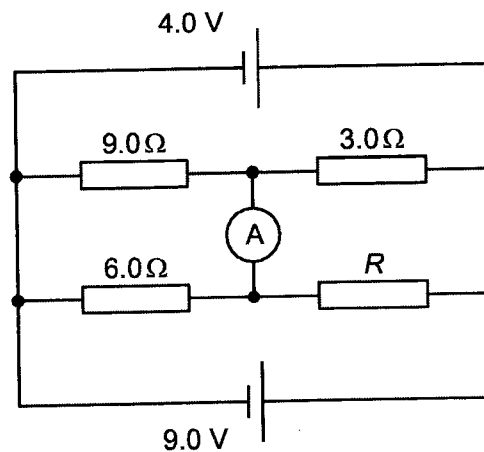
12

- 22 The diagram shows an electrical circuit consisting of a 1.5 V cell of negligible internal resistance and two resistors P and Q.



Which statement about this circuit is correct?

- A The cell converts 1.5 J of electrical energy to chemical energy for each coulomb of charge passing through it.
- B The energy dissipated per unit charge passing through P and Q is the same.
- C The potential difference across P and the potential difference across Q add up to 1.5 V.
- D The rate of flow of charge at point X is greater than the rate of flow of charge at Y.
- 23 In the circuit shown, the cells have negligible internal resistance and the reading on the ammeter is zero.

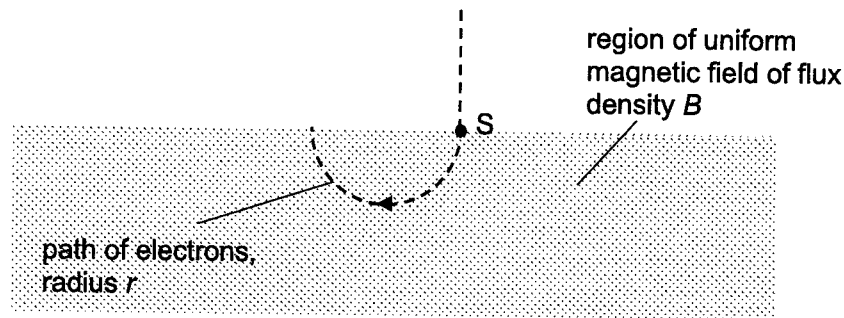


What is the resistance of R ?

- A $2.0\ \Omega$ B $6.0\ \Omega$ C $12\ \Omega$ D $18\ \Omega$

- 24 Electrons, each of mass m and charge q , are accelerated from rest in a vacuum through a potential difference V .

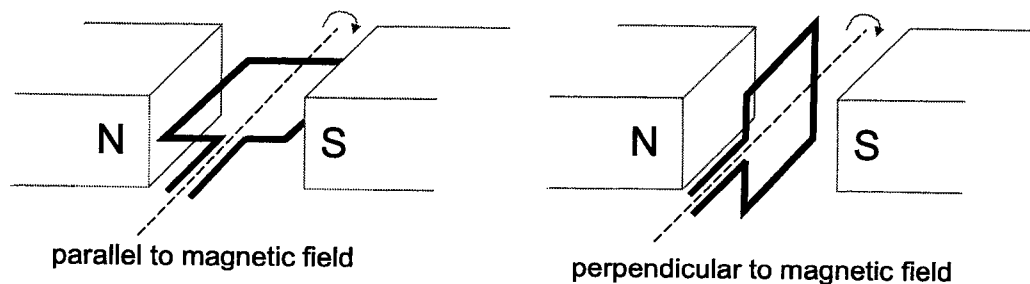
The accelerated electrons are then projected at point S into a region of uniform magnetic field of flux density B , as shown. The electrons move in a circular path of radius r .



Which of the following expressions represents the specific charge $\frac{q}{m}$ of the electrons?

- A $\frac{V}{2B^2r}$ B $\frac{2V}{B^2r}$ C $\frac{V}{2B^2r^2}$ D $\frac{2V}{B^2r^2}$

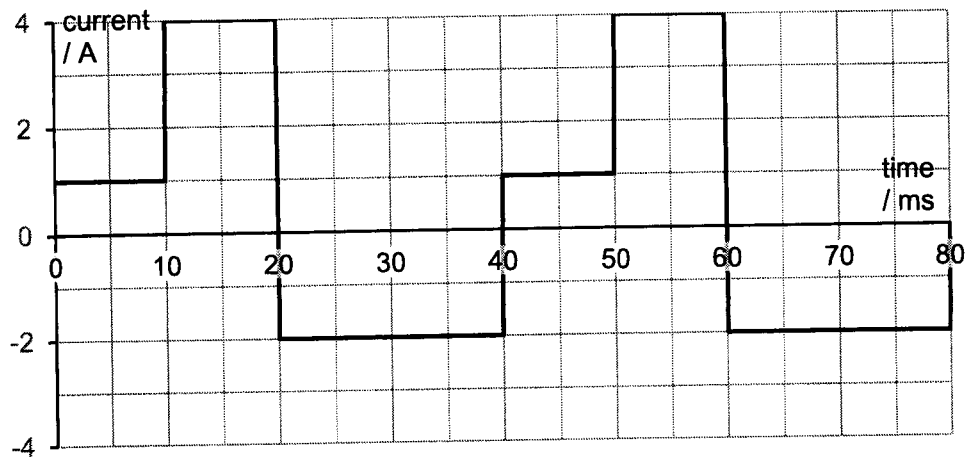
- 25 A rectangular coil made of 100 turns of wire with cross sectional area 30 cm^2 is placed within a uniform magnetic field of 0.80 T . The coil is rotated with an angular velocity of 100 rad s^{-1} . At different stages of its rotation, the cross sectional area of the coil can be parallel or perpendicular to the magnetic field, as shown.



What is the maximum e.m.f. induced and the corresponding orientation of the coil?

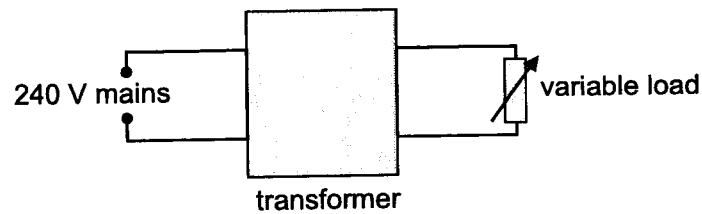
	maximum e.m.f. / V	orientation of coil
A	0.24	parallel to magnetic field
B	0.24	perpendicular to magnetic field
C	24	parallel to magnetic field
D	24	perpendicular to magnetic field

- 26 The graph below shows how the current in a coil varies with time.



What is the value of a steady current that will dissipate heat in the coil at the same average rate as the current above?

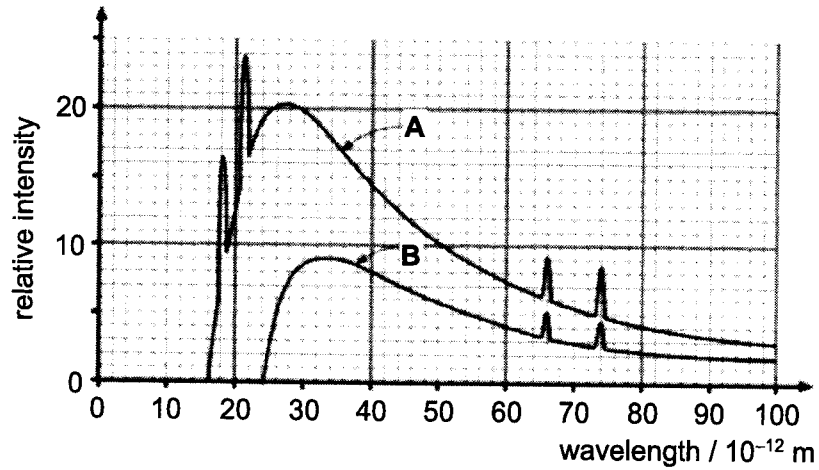
- A 1.5 A B 2.3 A C 2.5 A D 2.6 A
- 27 An ideal transformer steps down the 240 V sinusoidal voltage from the mains to 12 V, which is then applied to a variable load.



What is the change in the current supplied by the mains when the resistance of the load is increased from 20Ω to 50Ω ?

- A Decrease from 30 mA to 12 mA.
 B Increase from 12 mA to 30 mA.
 C Decrease from 12 mA to 4.8 mA.
 D Increase from 0.24 A to 0.60 A.

28 The diagram shows two spectra of X-rays from an X-ray tube.



Which of the following statements is true?

- A The accelerating potential to produce spectrum B is lower than that to produce spectrum A.
- B A different target metal is used to produce spectra A and B as shown from the existence of additional peaks in spectrum A.
- C With the same accelerating potential, the temperature of cathode used to produce spectrum A is higher than that to produce spectrum B as shown from the higher intensity of X-ray photons in spectrum A.
- D The temperature of cathode used to produce spectrum A is higher than that to produce spectrum B as shown from the existence of additional peaks in spectrum A.

29 Which of the following radioactive samples has the greatest activity?

	nuclide	amount / mole	half-life / day
A	${}_{89}^{225}\text{Ac}$	0.003	10
B	${}_{90}^{228}\text{Th}$	0.1	400
C	${}_{88}^{228}\text{Ra}$	0.6	2100
D	${}_{94}^{241}\text{Pu}$	1.0	4800

- 30 A radioactive source is placed 1 cm from a Geiger-Muller tube, and various absorbers are placed between them, one at a time. For each absorber, a one-minute count is taken of the total number of decays, and this is repeated several times. The table shows the results of the experiment.

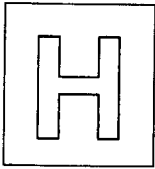
absorber	average number of decays detected in one minute
none	1043
0.1 mm paper	1040
1 mm aluminium	497
1 cm lead	6

The average background count per minute is 5.

What nuclear radiation do the results suggest the source was emitting?

- A alpha and beta only
- B beta only
- C beta and gamma only
- D alpha, beta and gamma

End of Paper



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PHYSICS

9749/02

Paper 2 Structured Questions

13 September 2022

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and tutor's name in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.

You may use a HB pencil for any diagrams, graphs.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
1	/ 8
2	/ 8
3	/ 8
4	/ 8
5	/ 9
6	/ 11
7	/ 8
8	/ 20
Total	/ 80

This document consists of **22** printed pages.

Answer **all** the questions in the space provided.

- 1 (a) A ball leaves the edge of a table with a horizontal velocity v , as shown in Fig. 1.1.

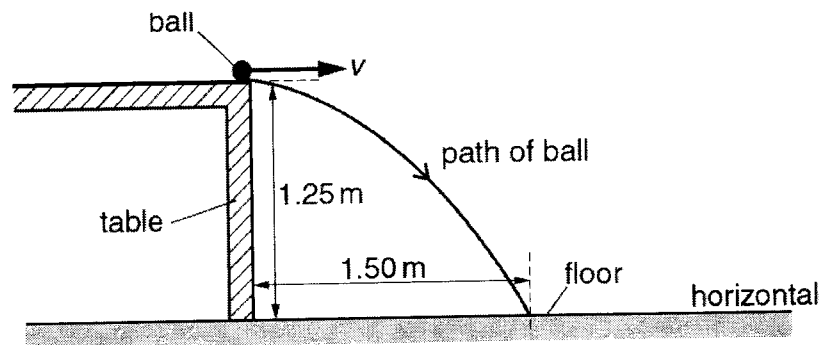


Fig. 1.1

The height of the table is 1.25 m. The ball travels a distance of 1.50 m horizontally before hitting the floor.

Air resistance is negligible.

Calculate, for the ball,

- (i) the horizontal velocity v as it leaves the table,

$$v = \dots\dots\dots \text{ m s}^{-1} [2]$$

- (ii) the velocity just before it hits the floor.

$$\text{velocity} = \dots\dots\dots \text{ m s}^{-1} [2]$$

(b) A second ball leaves the edge of the table with a horizontal velocity $2v$.

(i) State and explain whether the time taken to hit the floor is the same or different compared to the first ball.

.....
.....[2]

(ii) Describe the variation of the vertical component of velocity if air resistance is not negligible.

.....
.....[2]

[Total: 8]

- 2 (a) State Newton's Second Law of motion.

.....
[1]

- (b) A jet of water hits a vertical wall at right angles, as shown in Fig. 2.1. The jet of water has density ρ , cross-sectional area A , and hits the vertical wall with impact velocity u . The water then runs down the wall after impact with the wall.

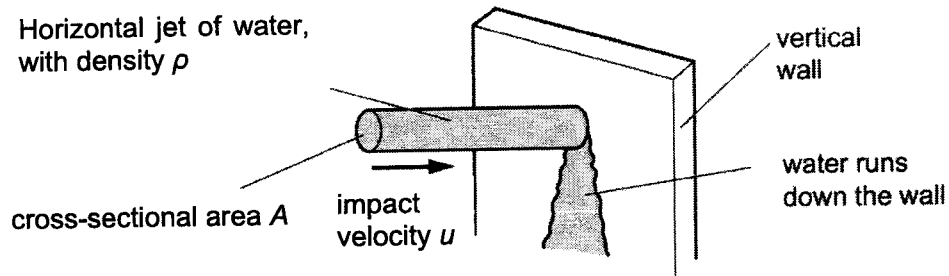


Fig. 2.1

- (i) Using Newton's Law of motion, show that the magnitude of the average force exerted on the water by the wall is

$$F = \rho Au^2.$$

[3]

- (ii) The density of water ρ is 1000 kg m^{-3} . Given that the jet of water in (b) has cross-sectional area A of 1.5 cm^2 and impact velocity u of 5.0 m s^{-1} ,
1. Calculate the magnitude of the average force exerted on the wall by the water. Explain your answer.

magnitude of average force = N [2]

2. On Fig. 2.2, sketch a graph to show the variation of pressure p on the wall with impact velocity u . [1]

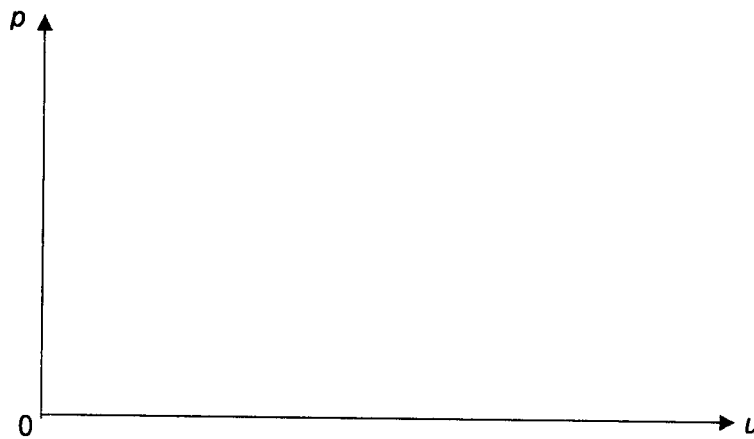


Fig. 2.2

3. Suggest the change, if any, to pressure p if the cross-sectional area A of the water jet is doubled.

.....
 [1]

[Total: 8]

- 3 A ball of mass M of 750 g is held on a smooth horizontal surface between two identical springs at their natural lengths as shown in Fig. 3.1.

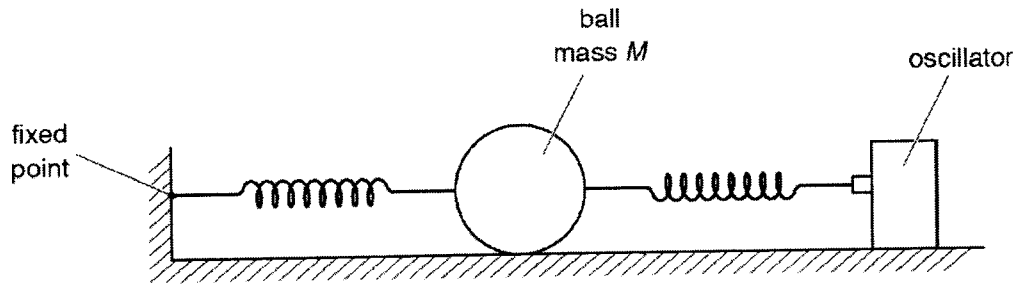


Fig. 3.1

One spring is attached to a fixed point while the other spring is attached to a mechanical oscillator. At $t = 0$ the ball is displaced to its amplitude position. The variation with time t of the displacement L of the ball is shown in Fig. 3.2.

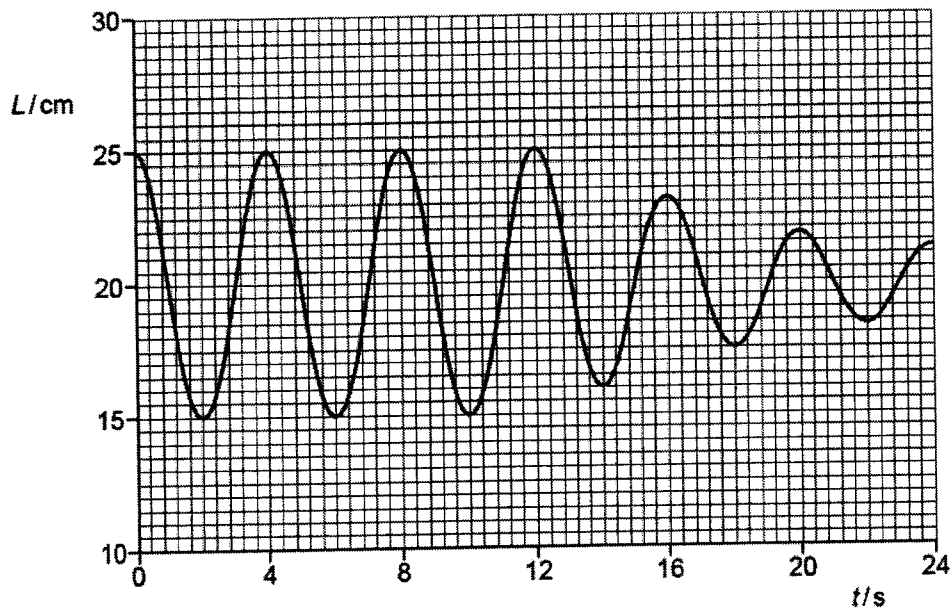


Fig. 3.2

(a) For the first 12 s of the oscillations,

- (i) state one time at which the ball is moving with maximum speed,

time = s [1]

- (ii) state one time at which the springs have maximum elastic potential energy,

time = s [1]

- (iii) calculate the angular frequency ω of the ball,

$\omega = \dots\dots\dots$ rad s⁻¹ [1]

7

(iv) calculate the maximum acceleration of the ball.

maximum acceleration = m s^{-2} [2]

(b) Some salt is sprinkled on the horizontal surface at $t = 12.0$ s.

Calculate the loss in total energy of the oscillations during the first 24 s of the oscillations.

Show your working clearly.

[3]

[Total: 8]

- 4 Microwaves of the same wavelength and amplitude are emitted in phase from two point sources X and Y, as shown in Fig. 4.1.

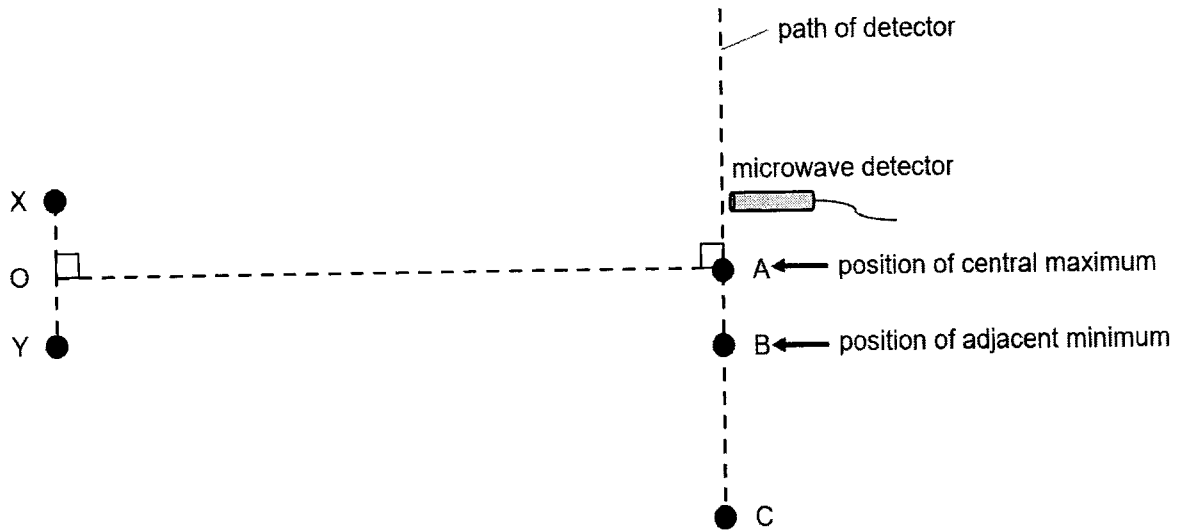


Fig. 4.1 (not to scale)

- (a) State and explain along which of the lines XY and OA do the microwaves superpose to produce a stationary wave.

.....
[2]

- (b) A microwave detector is moved along a line from A to C. The microwave detector gives a maximum intensity reading at A and the first minimum reading at B. The microwaves have a wavelength of 4.0 cm.

For the waves arriving at B, determine the path difference.

path difference = m [1]

(c) Describe the effect, if any, on the intensity of the microwave detected at A and B when the following changes are made, separately to the sources X and Y:

(i) when the amplitude of both source X and Y is doubled.

.....
.....
.....[2]

(ii) when the amplitude of one of the sources is halved.

.....
.....
.....[2]

(iii) when the sources are now anti-phase.

.....
.....[1]

[Total: 8]

- 5 Fig. 5.1 shows the electric field in the region between two points P and Q. The electric potential at P and at Q are +400 V and -400 V respectively.

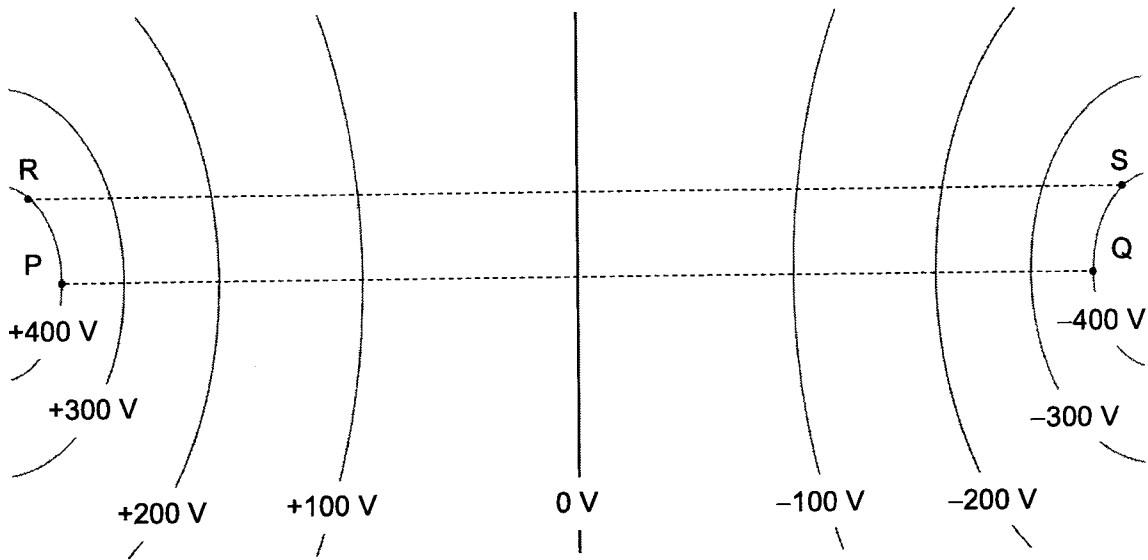


Fig. 5.1

- (a) Define *electric potential* at a point.

.....

[2]

- (b) Describe how the direction and magnitude of the electric field strength varies along the line PQ.

.....

[2]

- (c) An electron is projected from P towards Q with a speed of $2.2 \times 10^7 \text{ m s}^{-1}$. Calculate its speed when it reaches Q.

speed = m s^{-1} [3]

11

- (d) Another electron is projected from R towards S. Explain why this electron will not move in the path RS.

.....
.....[1]

- (e) Sketch a possible path taken by the electron in (d). [1]

[Total: 9]

12

- 6 (a) A cell of e.m.f. 1.5V and internal resistance $0.25\ \Omega$ is connected in series with a resistor R , as shown in Fig. 6.1.

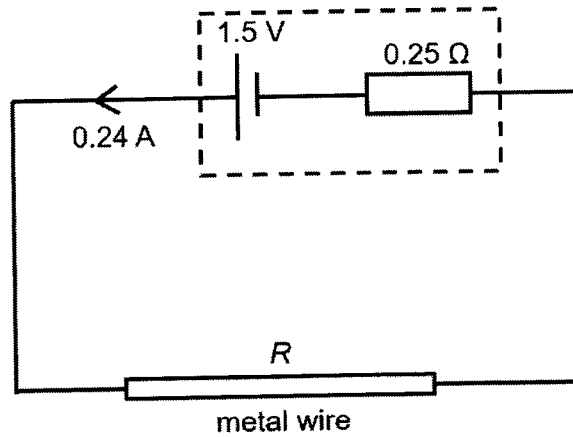


Fig. 6.1

The resistor R is made of metal wire.

A current of 0.24 A passes through R for a time of 5.0 minutes.

Calculate

- (i) the charge that passes through the cell,

charge = C [1]

- (ii) the total energy transferred by the cell,

energy = J [2]

- (iii) the energy transferred in the resistor R ,

energy = J [2]

(iv) the resistance of R.

resistance = Ω [2]

(b) Two cells identical to the one in (a) are now connected in series with a fixed resistor of resistance 2000Ω and a thermistor, as shown in Fig. 6.2.

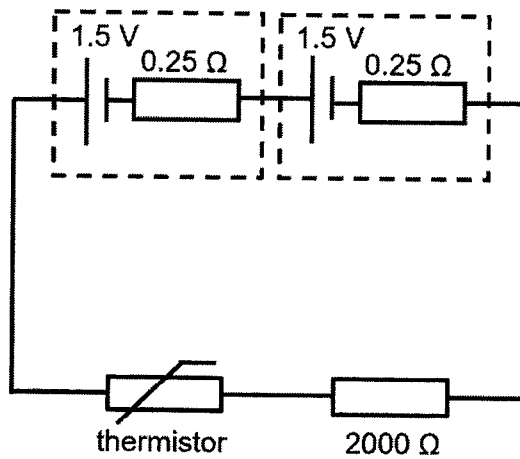


Fig. 6.2

The thermistor has resistance 4000Ω at 0°C and 1800Ω at 20°C .

(i) Explain why, in this circuit, the internal resistance of the cells may be considered to be negligible.

.....
.....
.....[1]

- (ii) In one particular application of the circuit of Fig. 6.2, it is desired that the potential difference across the **fixed** resistor should range from 1.2 V at 0 °C to 2.4 V at 20 °C.

Determine whether it is possible to achieve this range of potential differences.

.....

.....

.....[3]

[Total: 11]

7 (a) Distinguish between the appearance of emission and absorption line spectra.

.....
[2]

(b) The lowest six discrete energy levels for a hydrogen atom are shown in Fig. 7.1, where the ground state is -13.6 eV .

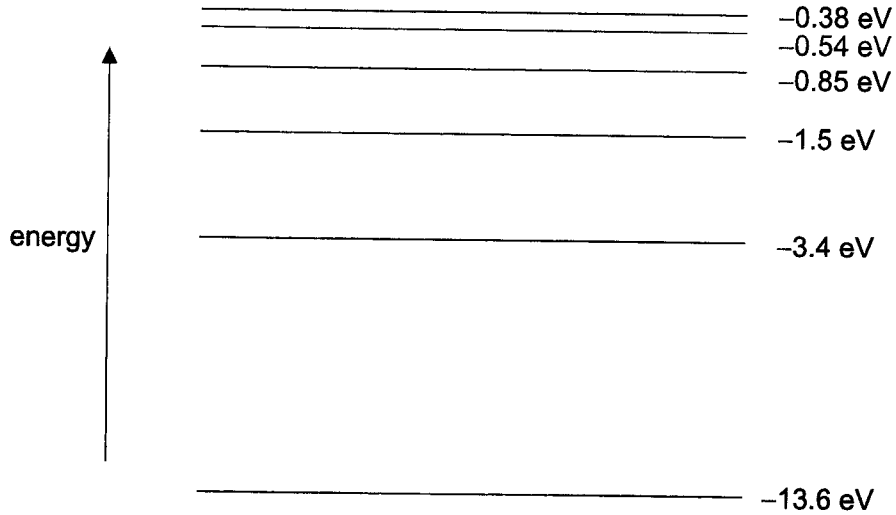


Fig. 7.1 (not to scale)

(i) The spectrum produced by hydrogen is a line spectrum. Use Fig. 7.1 to explain why the spectrum is a line spectrum rather than a continuous spectrum.

.....

[2]

(ii) Describe one way by which an electron in gaseous hydrogen can be raised from a ground state to the -0.54 eV energy level.

.....

[1]

(iii) State the total number of different wavelengths that may be emitted as the electron de-excites from the -0.54 eV energy level.

number =[1]

16

- (iv) Electromagnetic radiation is emitted when an electron falls to the ground state from the -0.54 eV energy level.

Calculate the wavelength of this radiation. Suggest the type of radiation emitted.

wavelength = m

type of radiation =

[2]

[Total: 8]

- 8 Read the passage below and answer the questions that follow.

Optical Tweezers

In early 1970s, Arthur Ashkin first reported the observation of micron-sized particles being accelerated and trapped in stable optical potential wells by utilising only the radiation pressure caused by continuous laser. This led to the development of a single-beam, gradient force optical trap, commonly known as Optical Tweezers.

Optical tweezers have since been used in fields ranging from fundamental physical sciences to biology, performing single molecule force and motion measurements, and non-invasively manipulating objects such as DNA and live single cells.

Optical tweezers have the ability of applying pico-newton forces to micron-sized particles. In such systems, transparent dielectric particles made of glass or polystyrene are commonly used as they have higher index of refraction than their surrounding medium (typically liquid), thus attracting them toward the region of maximum laser intensity.

An optical trap uses forces exerted by a highly focused monochromatic laser beam in order to trap and manipulate microscopic dielectric objects. The beam is focused through a microscope objective lens in order to produce a narrow beam waist as shown in Fig. 8.1. Dielectric particles suspended in the surrounding liquid medium will be attracted to the centre of the beam waist and towards the optical axis as shown in Fig. 8.2, where it is the region of maximum laser intensity. The laser intensity decreases with distance from the optical axis.

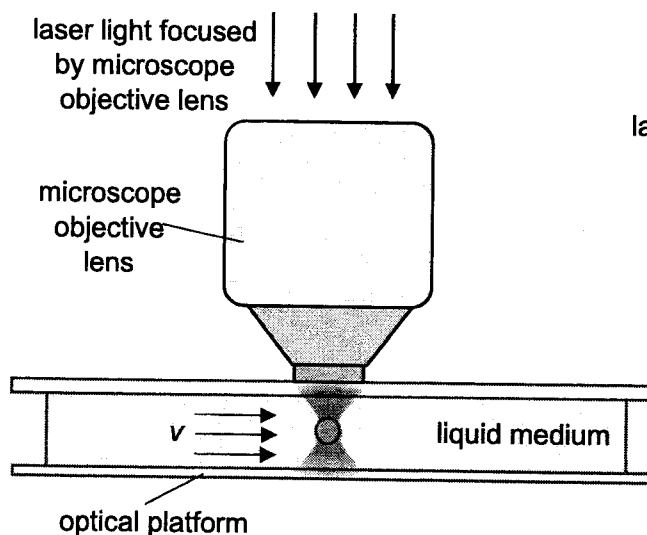


Fig. 8.1

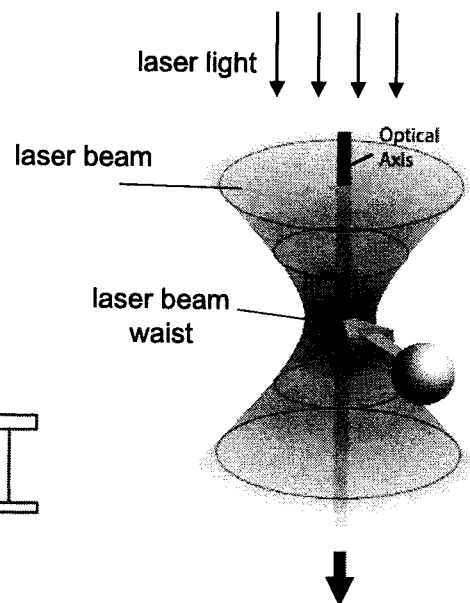


Fig. 8.2

For particles of radius much larger than the wavelength λ of the laser, the Mie scattering approach is utilised. The laser beam is made up of a stream of photons. Some incident photons are reflected by the dielectric sphere, while the rest are refracted through the dielectric sphere. The reflected and refracted processes lead to a change in the momentum of the photons, producing a resultant force on the sphere, which is proportional to the light intensity of the incident laser. With a dielectric sphere of refractive index larger than that of the liquid medium, the refracted light will induce a force in the direction of the intensity gradient, causing the sphere to move towards the centre of the beam waist.

Using the Mie approach, geometric optics is used for the calculation of optical forces. A simplified ray diagram of the refracted laser beam is shown in Fig. 8.3, where two beams G and H pass from a liquid medium through a polystyrene sphere. The sphere experiences a net force towards the centre of the laser waist beam due to both refracted and reflected beams of beams G and H. The sphere will then be stably trapped, with the centre of the sphere aligned with the optical axis.

The force due to the reflected beam may be taken to be negligible, compared to that due to the refracted beam.

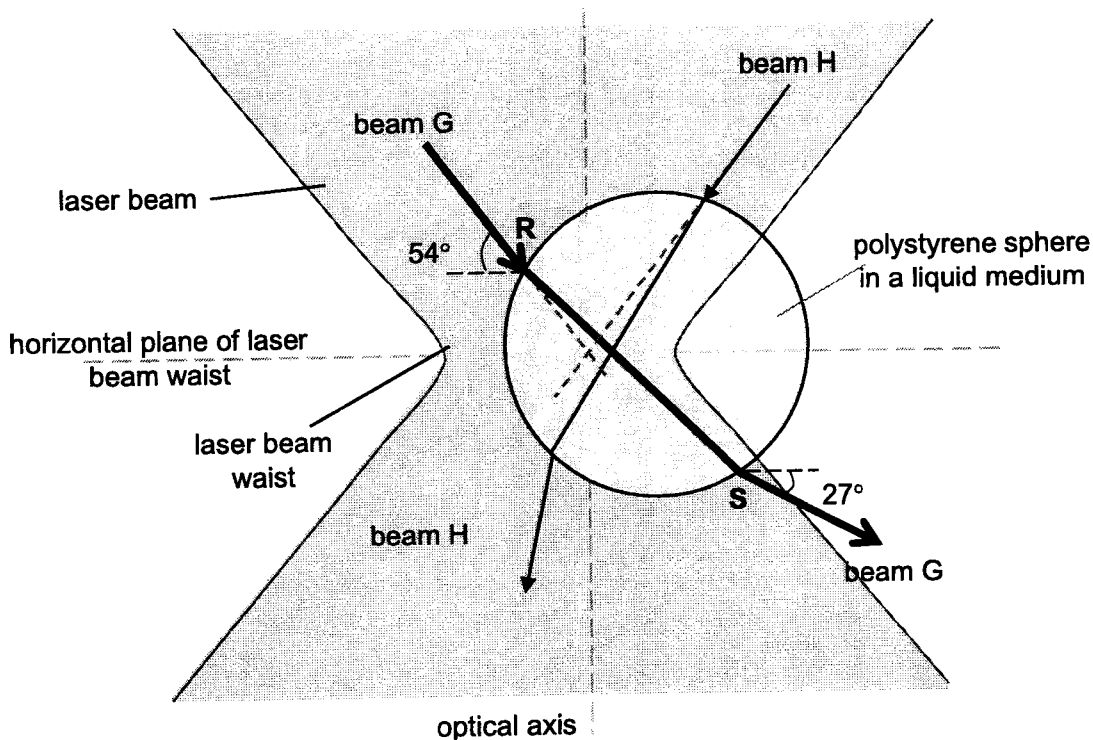


Fig. 8.3 (Reflected beams not drawn)

When the centre of a trapped sphere is displaced by a small displacement Δx from the equilibrium position, there is a restoring force F which obeys Hooke's law where

$$F = k\Delta x$$

and k is the trap stiffness.

The restoring force F can be determined using the Stoke's method, by allowing a fluid of known velocity v to flow past the sphere and measuring the corresponding displacement Δx as shown in Fig. 8.4. The viscous drag F_{drag} acting on the sphere is given by the relationship

$$F_{\text{drag}} = 6\pi r\eta v$$

where r is the radius of the sphere, η is the fluid viscosity and v is the velocity of fluid flow.

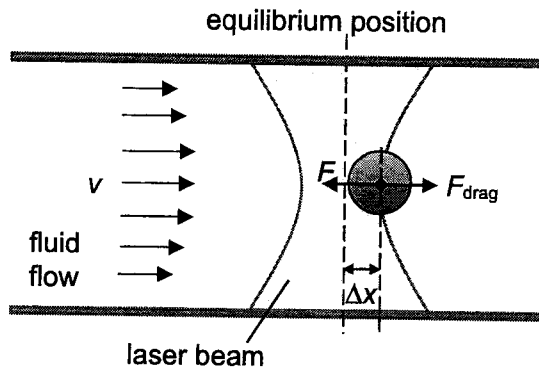


Fig. 8.4

The optical trap can then be calibrated to obtain the trap stiffness k for molecular force measurements.

(a) Suggest why opaque particles are not used for optical tweezer manipulation.

.....

[1]

(b) A laser of wavelength 603 nm is used for trapping polystyrene spheres.

With reference to Fig. 8.3, laser beam G with photons of total momentum p_i in unit time is incident on the sphere at R at an angle of 54° to the horizontal, and exits at S with total momentum p_f in unit time at an angle 27° to the horizontal.

(i) For laser beam G, sketch a vector diagram to show the total initial momentum p_i , total final momentum p_f , and total change in momentum Δp of the photons in unit time. Label the vectors clearly.

[2]

(ii) With reference to your answer in (b)(i) and using Newton's laws of motion, explain how the refracted laser beam G gives rise to a force acting on the sphere.

.....

[2]

20

(iii) Calculate the momentum of a single photon.

momentum = N s [2]

(iv) Using your answer in (b)(i), show that the change in momentum of one photon is 5.14×10^{-28} N s.

[1]

(v) The force on the sphere due to laser beam G is 16 pN.

Hence calculate the number of photons in laser beam G passing through the sphere in unit time.

number of photons = [2]

(vi) Due to laser beams G and H, the sphere experiences a net force of 19 pN towards the centre of the beam waist.

Calculate the magnitude of the force due to beam H.

magnitude of force = N [3]

(vii) Suggest why laser beam G produces a larger force on the sphere as compared to laser beam H.

.....
.....
.....[1]

(c) An optical tweezer system is calibrated using the Stoke's method by trapping a polystyrene sphere of diameter 4.0 μm in liquid as shown in Fig. 8.4. Values for v and Δx are obtained from the experiment and the values are plotted on the graph of Fig. 8.5.

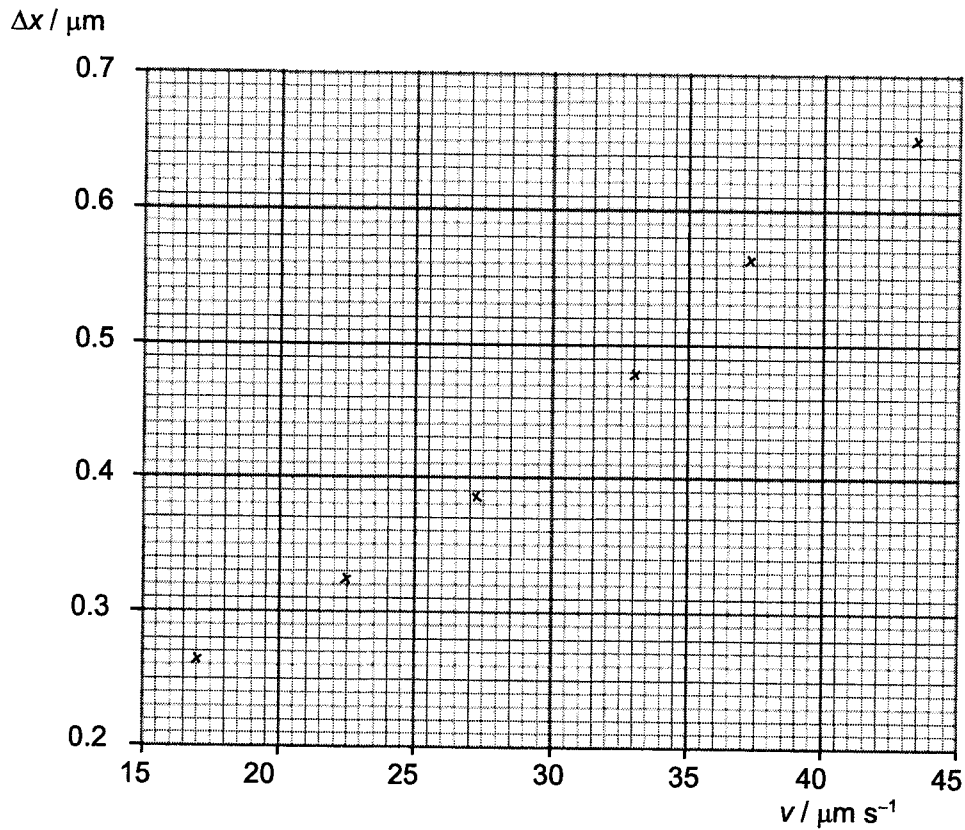


Fig. 8.5

(i) Determine the base units of viscosity η .

SI base units = [1]

(ii) On Fig. 8.5, draw the line of best fit for all the points. [1]

(iii) Determine the gradient of the line drawn in (c)(ii).

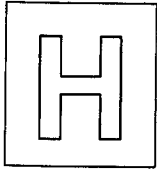
gradient = [2]

(iv) Hence, determine the trap stiffness k of this optical tweezer system, given that the value of η is 0.890×10^{-3} .

$k = \dots\dots\dots$ N m⁻¹ [2]

[Total: 20]

End of Paper



NANYANG JUNIOR COLLEGE
 JC 2 PRELIMINARY EXAMINATION
 Higher 2

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CLASS

TUTOR'S
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INDEX
 NUMBER

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PHYSICS

9749/03

Paper 3 Longer Structured Questions

19 September 2022

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class, Centre number and index number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.

You may use a HB pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** questions.

Section B

Answer **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
Section A	
1	/ 8
2	/ 12
3	/ 8
4	/ 9
5	/ 6
6	/ 9
7	/ 8
Section B	
8	/ 20
9	/ 20
Total	/ 80

This document consists of **24** printed pages.

Data

speed of light in free space
 permeability of free space
 permittivity of free space

elementary charge
 the Planck constant
 unified atomic mass constant
 rest mass of electron
 rest mass of proton
 molar gas constant
 the Avogadro constant
 the Boltzmann constant
 gravitational constant
 acceleration of free fall

$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$$

$$(1 / (36\pi)) \times 10^{-9} \text{ F m}^{-1}$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$h = 6.63 \times 10^{-34} \text{ J s}$$

$$u = 1.66 \times 10^{-27} \text{ kg}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg}$$

$$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

$$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$$

$$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

$$g = 9.81 \text{ m s}^{-2}$$

Formulae

uniformly accelerated motion

work done on / by a gas
 hydrostatic pressure
 gravitational potential
 temperature

pressure of an ideal gas

mean translational kinetic energy of an ideal molecule

displacement of particle in s.h.m.
 velocity of particle in s.h.m.

electric current
 resistors in series
 resistors in parallel

electric potential

alternating current/voltage

magnetic flux density due to a long straight wire

magnetic flux density due to a flat circular coil

magnetic flux density due to a long solenoid

radioactive decay

decay constant

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$W = p\Delta V$$

$$p = \rho gh$$

$$\phi = -Gm/r$$

$$T / \text{K} = T / ^\circ\text{C} + 273.15$$

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

$$E = \frac{3}{2}kT$$

$$x = x_0 \sin \omega t$$

$$v = v_0 \cos \omega t$$

$$= \pm \omega \sqrt{x_0^2 - x^2}$$

$$I = Anvq$$

$$R = R_1 + R_2 + \dots$$

$$1/R = 1/R_1 + 1/R_2 + \dots$$

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

$$x = x_0 \sin \omega t$$

$$B = \frac{\mu_0 I}{2\pi d}$$

$$B = \frac{\mu_0 NI}{2r}$$

$$B = \mu_0 nI$$

$$x = x_0 \exp(-\lambda t)$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

3

Section A

Answer **all** the questions in the spaces provided.

- 1 Fig. 1.1 shows a man standing on a stationary sailboard floating in the sea. The sailboard consists of a surfing board, mast and sail.

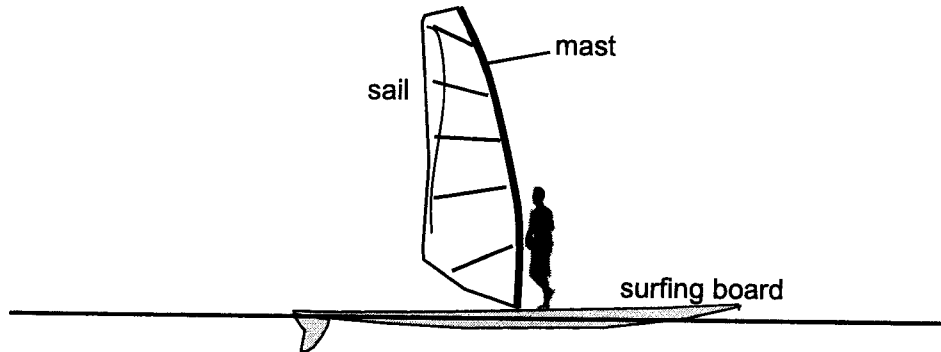


Fig. 1.1

- (a) The total mass of the sailboard and the man is 90 kg. Taking the density of seawater to be 1020 kg m^{-3} , calculate the volume of seawater displaced by the sailboard.

volume of seawater displaced = m^3 [2]

4

- (b) The sailboard then cruises at constant speed. Fig. 1.2 shows some of the forces acting on the mast and sail of the sailboard.

The uniform mast has length 4.3 m and the base of the mast is connected to the surfing board by a smooth hinge. The wind exerts a force of 200 N on the sail, perpendicular to the mast at a distance 3.5 m away from the hinge.

The man pulls the sail with a force T at distance 1.5 m away from the hinge and the weight of the mast and sail is 50 N.

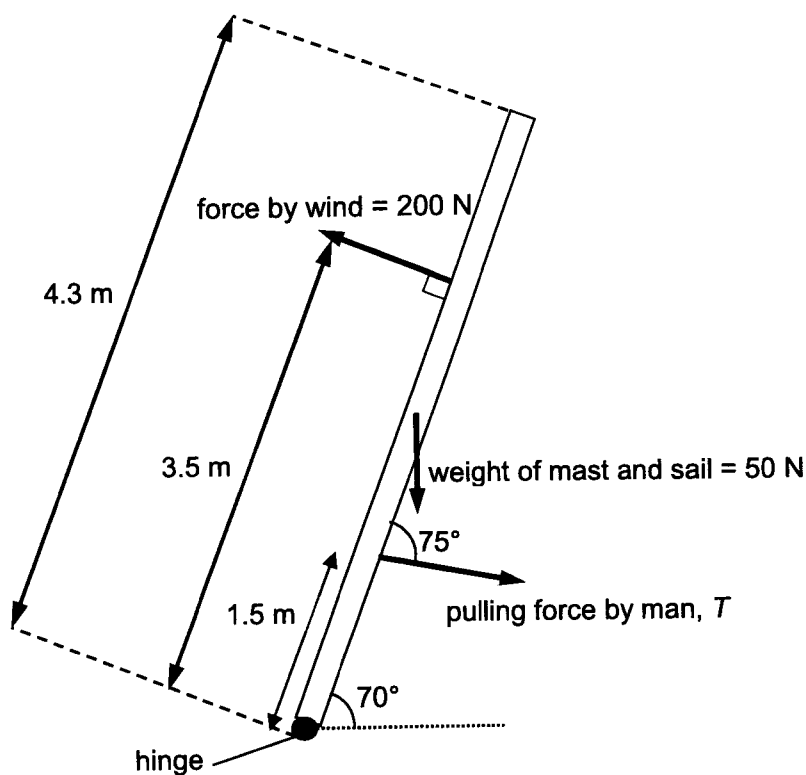


Fig. 1.2

- (i) Show that pulling force T by the man is 460 N.

[2]

(ii) Determine the magnitude of the force, R , exerted by the hinge.

magnitude of R = N [3]

(c) The surfing board is designed with the foot straps at the rear part of the board rather than at the centre part of the board, as shown in Fig. 1.3.

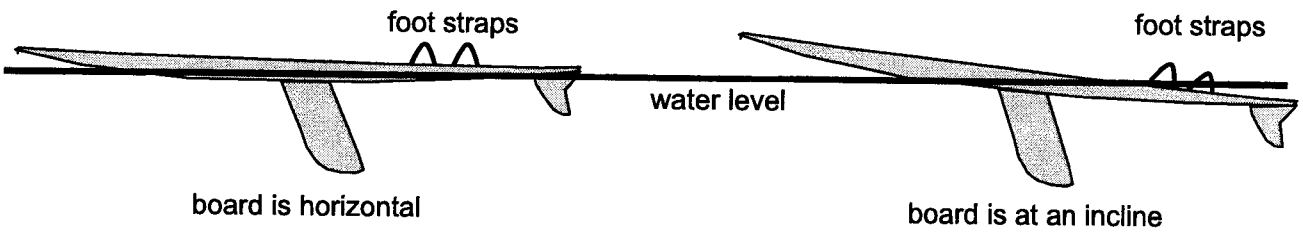


Fig. 1.3

Such a design allows the surfing board to move across the water surface while inclined at an angle to the surface.

Suggest why when the man is moving horizontally with the board at an incline, the volume of seawater displaced by the sailboard is lower than your answer in (a).

.....

.....

.....[1]

[Total: 8]

- 2 (a) Planets have been observed orbiting a star in another solar system. Measurements are made for the orbital radius r and the time period T of each of these planets.

The variation with r^3 of T^2 is shown in Fig. 2.1.

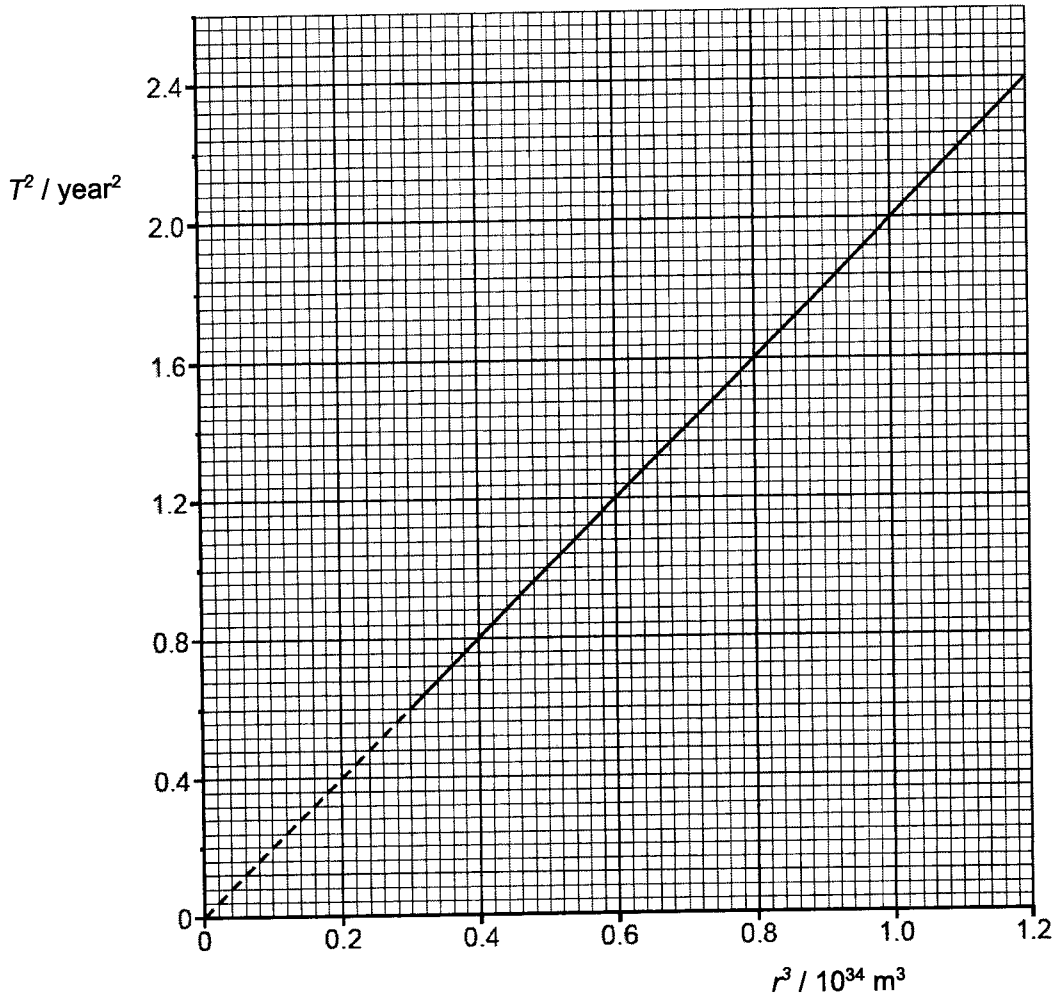


Fig. 2.1

The relationship between T and r is given by

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where G is the gravitational constant and M is the mass of the star.

7

- (i) Determine the mass M of the star.

$M = \dots\dots\dots$ kg [2]

- (ii) The radius of the star is 700 000 km. Determine the minimum speed with which gas particles from its surface have to be ejected to just escape from the star's pull of gravity.

minimum speed = $\dots\dots\dots$ m s⁻¹ [2]

- (iii) Hydrogen gas, consisting of hydrogen-2 particles, may be assumed to be an ideal gas. If the surface temperature of the star is 6000 K, determine whether hydrogen gas particles are able to escape the surface.

.....
 [2]

- (iv) Some gas particles have very large kinetic energy to be able to escape from the star.

Given that the star is rotating about an axis through its poles, suggest why the gas particles at the equator of the star are more likely to escape the surface than those at the poles.

.....

 [2]

(b) A satellite of mass m is also in orbit around the star in (a). The radius of the orbit is r .

(i) Show that the kinetic energy E_k of the satellite is given by

$$E_k = \frac{GMm}{2r}.$$

[1]

(ii) On Fig. 2.2, sketch graphs to show the variation with orbital radius r of the

1. gravitational potential energy of the satellite. Label the graph U.
2. kinetic energy of the satellite. Label the graph K.
3. total energy of the satellite. Label the graph T.

[3]

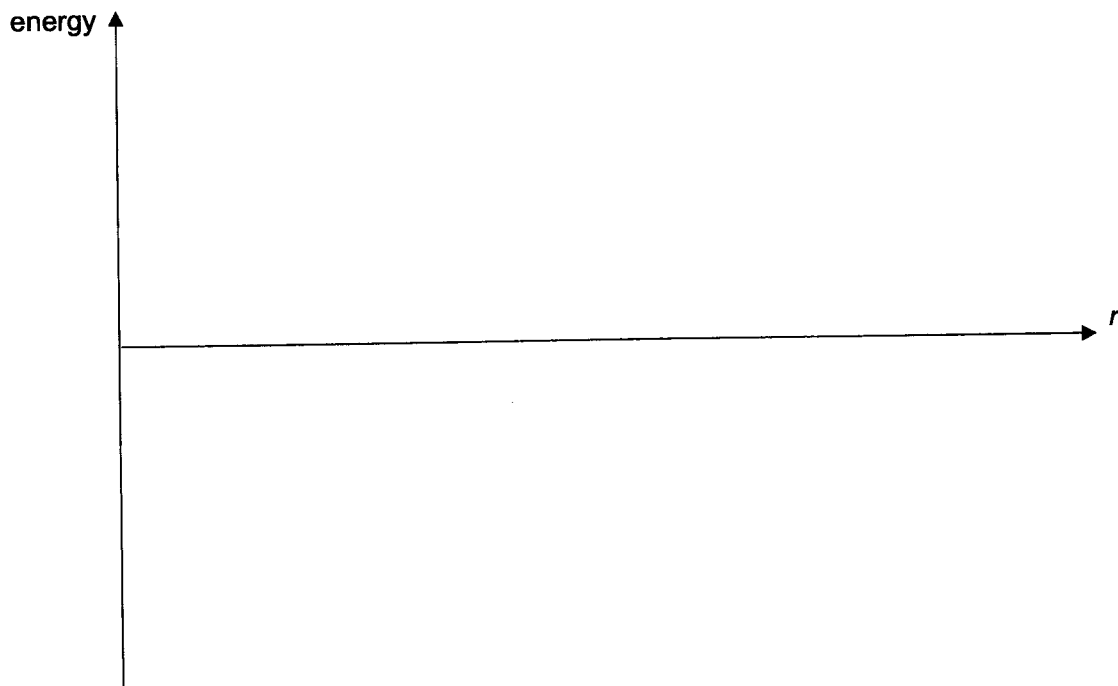


Fig. 2.2

[Total: 12]

- 3 A roller coaster ride in an amusement park consists of an unpowered car moving freely along a smooth track. Fig. 3.1 shows the roller coaster car moving with speed v at the top of a vertical loop with radius R . Ignore any resistive forces on the car.

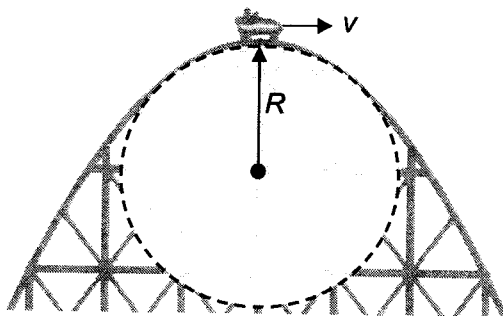


Fig. 3.1

- (a) For the car to remain in contact with the track at the top of the loop, show that the maximum speed v_{\max} of the car is

$$v_{\max} = \sqrt{Rg}.$$

Explain your working.

[3]

- (b) The entire roller coaster ride consists of two of such vertical loops with positions A and B as shown in Fig. 3.3. The two loops have radii R_1 and R_2 respectively.

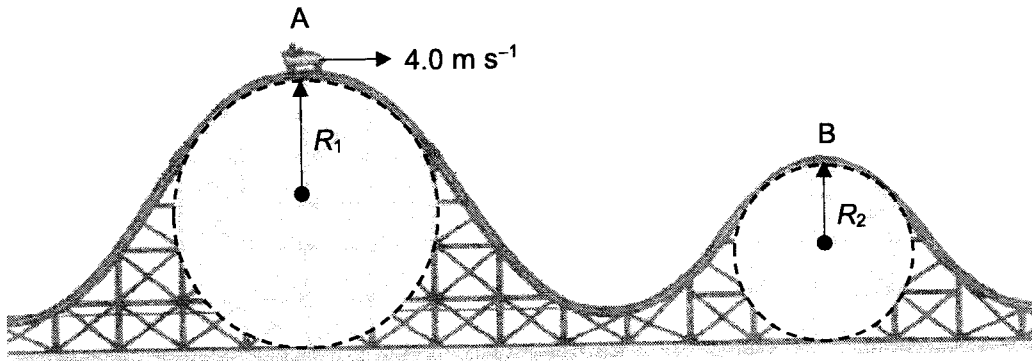


Fig. 3.3

During a test run, the car has a speed of 4.0 m s^{-1} at A where radius of the first loop R_1 is 15 m. Determine the minimum radius R_2 so that the car will remain in contact with the track throughout its journey.

$R_2 = \dots\dots\dots \text{ m [3]}$

- (c) Fig. 3.4 shows the car when it is at position C after it leaves A.

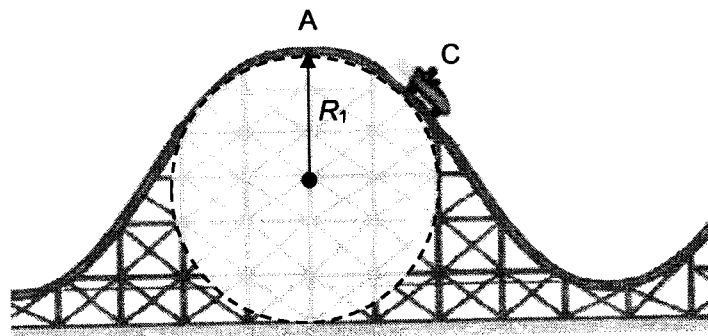


Fig. 3.4

On Fig. 3.4, draw an arrow to show the resultant force on the car at point C. Explain your answer.

.....

 [2]

[Total: 8]

4 (a) Explain what is meant by an *ideal gas*.

.....
.....[1]

(b) A fixed mass of ideal gas has a volume of 210 cm³ at pressure 3.0 × 10⁵ Pa and a temperature of 35 °C.

(i) State and explain the assumption of the kinetic theory that allows a gas to maintain its temperature.

.....
.....
.....[2]

(ii) The volume of the gas is then reduced at constant pressure to 140 cm³ by a moving piston. Determine the final temperature of the gas.

temperature of gas = K [2]

(iii) Calculate the average kinetic energy of a gas molecule at this final temperature.

average kinetic energy = J [2]

(iv) Using the first law of thermodynamics, explain whether heat is supplied to or released by the gas.

.....
.....
.....[2]

[Total: 9]

- 5 Source S_1 , consisting of parallel light with wavelength 700 nm, is incident on a rectangular slit of width b , as shown in Fig. 5.1.

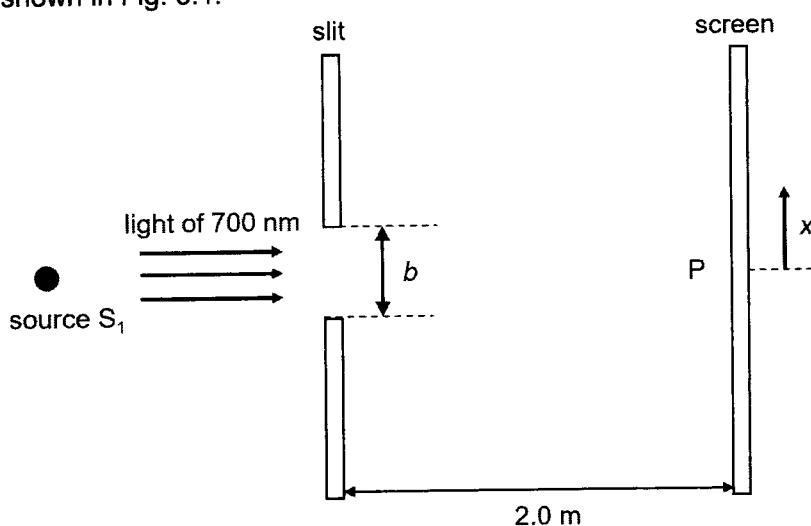


Fig. 5.1 (not to scale)

- (a) A central maxima is observed on the screen and its width is found to be 4.0 mm. Calculate the width b of the single slit.

slit width $b = \dots\dots\dots\text{ m}$ [2]

- (b) Fig. 5.2 shows the variation with distance x from P of the intensity I of the red light on the screen. Label, on Fig. 5.2, the values of the six x -intercepts. [2]

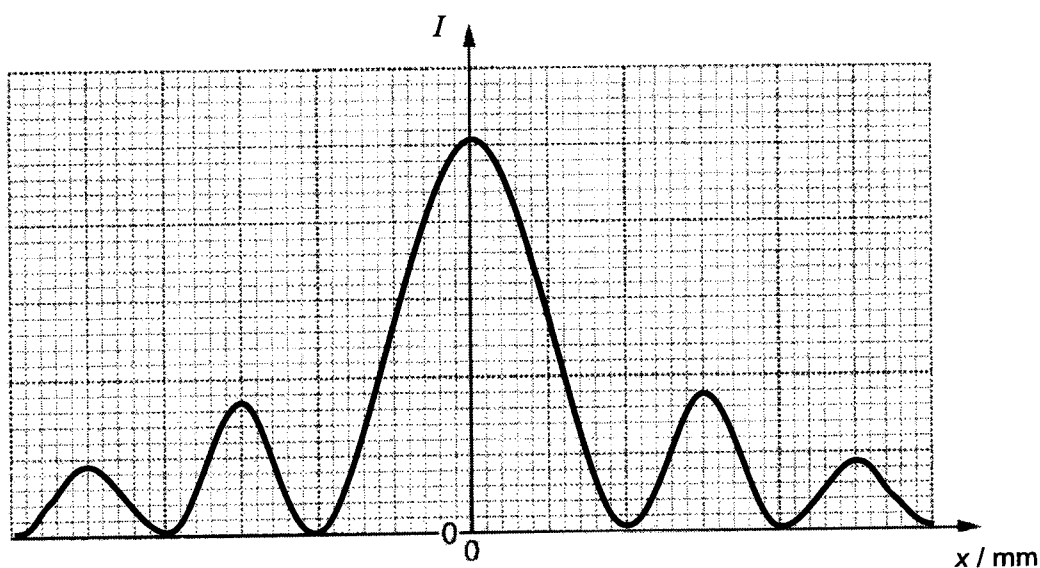


Fig. 5.2

(c) Another identical point source S_2 is placed close to S_1 as shown in Fig. 5.3.

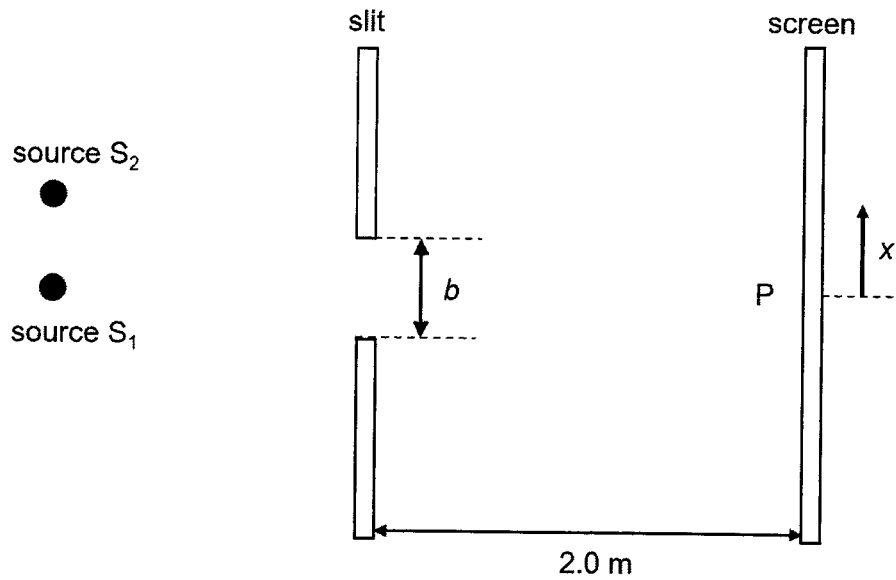


Fig. 5.3 (not to scale)

Sketch, on Fig. 5.2, the variation with distance x from P of the intensity I of the second source S_2 when Rayleigh criterion is satisfied. [2]

[Total: 6]

6 (a) Define *magnetic flux*.

.....

[2]

(b) A uniform conducting bar XY is pulled horizontally across long parallel frictionless conducting guide rails by a light inextensible string. The string passes over a frictionless pulley and is attached to a hanging block. The guide rails are placed in a vertical magnetic field of uniform magnetic flux density as shown in Fig. 6.1.

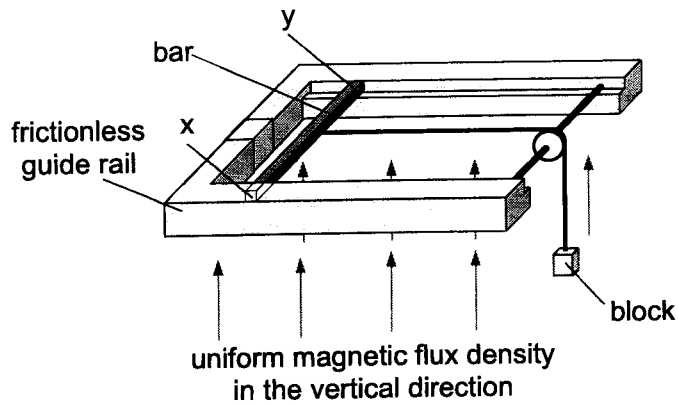


Fig. 6.1

The block is released from rest at time $t = 0$ s, and the bar starts to move.

(i) An e.m.f. is induced in the bar. State which end X or Y of the bar is at a higher potential.

.....[1]

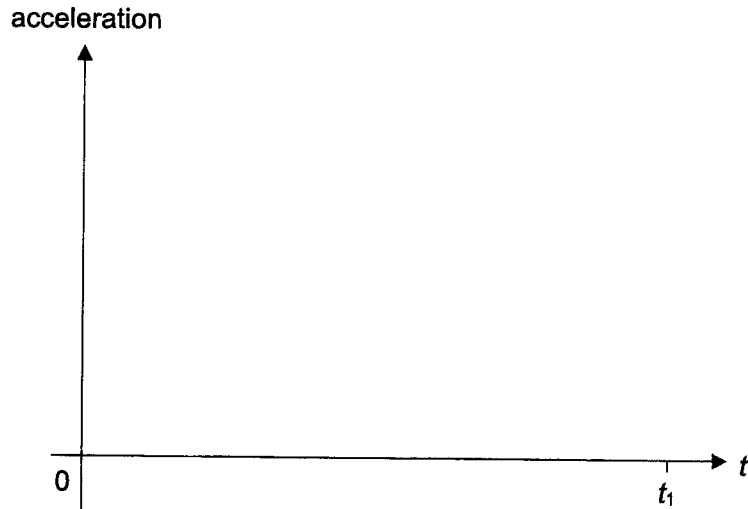
(ii) Use Faraday's law and Lenz's law to explain the subsequent motion of the bar.

.....

[4]

- (iii) In time t_1 , the bar slides along the length of the guide rails until it reaches a position just before the pulley.

On Fig. 6.2, sketch a graph to show the variation with time t of the acceleration of the rod from $t = 0$ to time $t = t_1$. Label clearly the acceleration at $t = 0$ as a .



[2]

[Total: 9]

- 7 (a) A beam of electrons is accelerated through a potential difference of 130 V and is then incident on a thin silicon crystal.

(i) State what is meant by *de Broglie wavelength*.

.....
 [1]

(ii) Show that the de Broglie wavelength of the electrons is 1.08×10^{-10} m.

[3]

- (b) A fluorescent screen is positioned 12 cm away from the silicon crystal as shown in Fig. 7.1. The separation of silicon atoms in a silicon crystal is 0.235 nm.

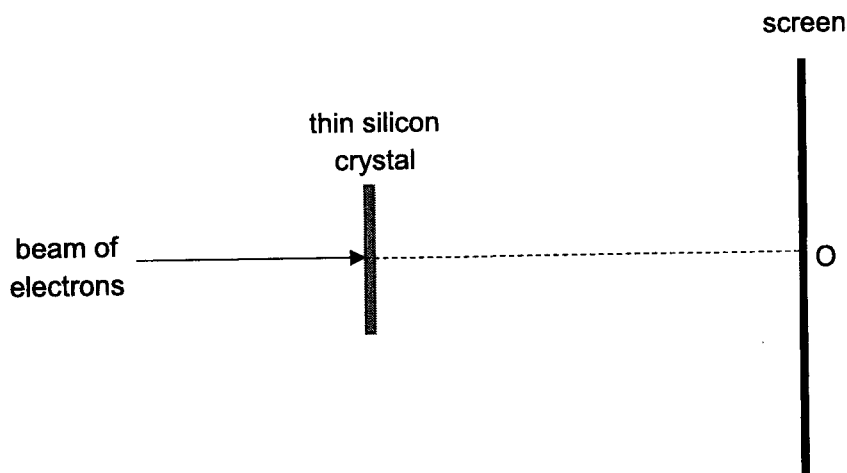


Fig. 7.1

(i) Explain why electron diffraction will be observed on the fluorescent screen.

.....
 [1]

- (ii) Electrons are observed in the straight-through direction at position O as shown in Fig. 7.1 and Fig. 7.2. Assume that the silicon crystal acts as a diffraction grating.

Draw to scale, on Fig. 7.2, the resulting diffraction pattern for the 1st order maxima. Show your working.

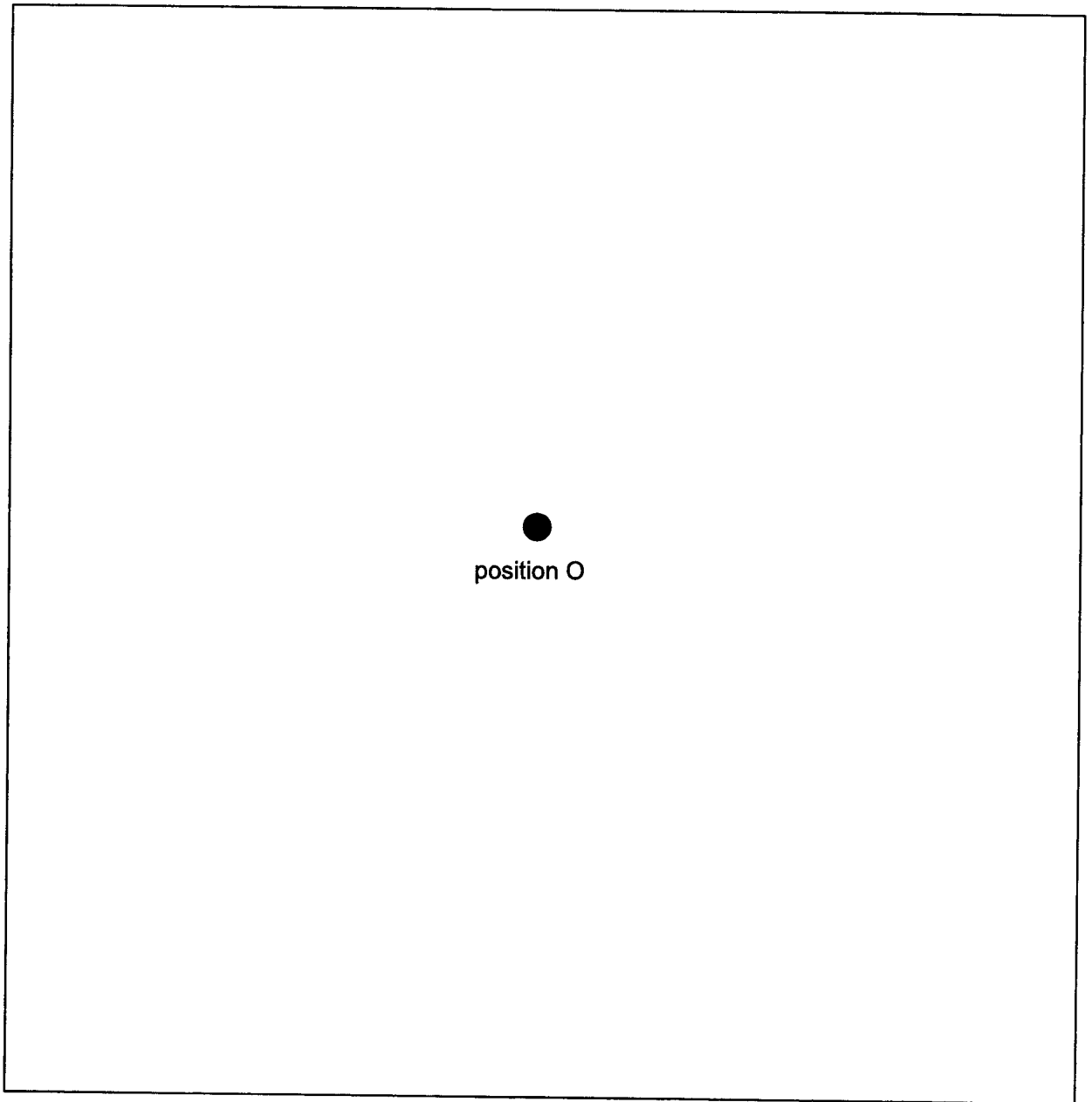


Fig. 7.2

[3]

[Total: 8]

Section B

Answer **one** question from this Section in the spaces provided.

- 8 Fig. 8.1 shows a thin iron strip of length 8.0 cm, width 2.0 cm and thickness 2.0 mm. As iron is a conductor of electricity, it contains free electrons, one of which is shown in Fig. 8.1.

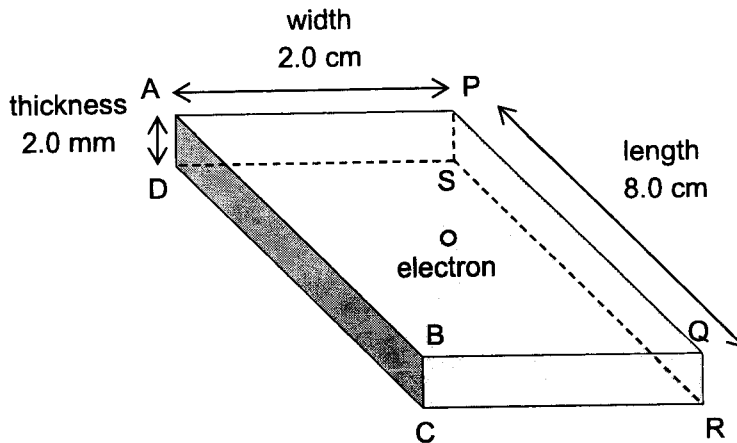


Fig. 8.1

- (a) A small potential difference is applied to the iron strip such that face ABCD is at a potential 12 mV higher than face PQRS.
- (i) Draw, on Fig. 8.1, an arrow to show the direction of the force on the free electron. Label as F_1 . [1]
- (ii) Calculate the magnitude of the force in (a)(i).

force = N [2]

- (iii) Determine the change in the electric potential energy of the electron when it moves across the entire width of the strip.

change in electric potential energy = J [2]

- (b) Iron has a resistivity of $9.7 \times 10^{-8} \Omega \text{ m}$ and an electron density of $8.8 \times 10^{28} \text{ m}^{-3}$.
- (i) Calculate the current in the iron strip when there is a potential difference of 12 mV across faces ABCD and PQRS.

current = A [3]

- (ii) Hence, show that the drift velocity of the electrons is $4.4 \times 10^{-4} \text{ m s}^{-1}$.

[1]

- (c) A magnetic field of flux density 20 mT is now applied in the downward direction into face ABQP.

- (i) Explain what is meant by a magnitude of 20 mT.

.....

 [1]

- (ii) Draw, on Fig. 8.1, an arrow to show the direction of the force exerted by the magnetic field on the electron. Label as F_B . [1]

- (iii) Calculate the magnitude of the force in (c)(ii).

force = N [2]

(iii) Explain why a potential difference develops across faces APSD and BQRC.

.....

.....

.....[1]

(iv) Draw, on Fig. 8.1, an arrow to show the direction of the force due to the potential difference/electric field in (c)(iii) on the electron. Label as F_E . [1]

(v) The potential difference in (c)(iii) eventually reaches a steady value. State the magnitude of the resultant force on the electron.

resultant force = N [1]

(vi) Hence calculate the value of the potential difference in (c)(iii).

potential difference = V [2]

(vii) This iron strip can be used in a device called the Hall probe to determine the magnitude and direction of flux density in a region of space.

Briefly explain how this iron strip can be used to determine the direction of another magnetic field.

.....

.....

.....

.....[2]

[Total: 20]

9 (a) Radioactive decay is a random and spontaneous process.

Explain what is meant by

(i) a *random* process,

.....
[1]

(ii) a *spontaneous* process.

.....
[1]

(b) An unstable nucleus of mass number A undergoes α -decay, as illustrated in Fig. 9.1.

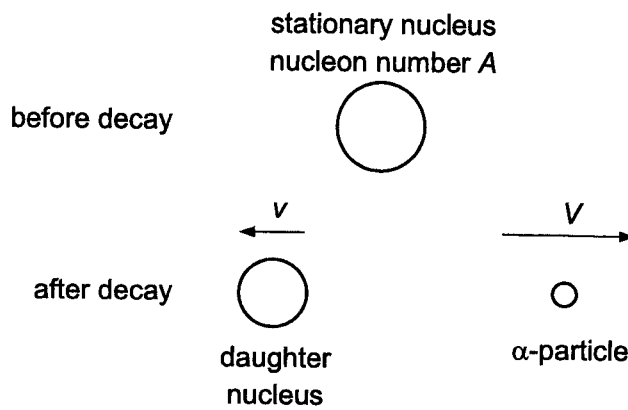


Fig. 9.1

The nucleus is stationary before the decay.

After the decay, the initial speed of the α -particle is V and that of the daughter nucleus is v .

(i) Derive an equation, in terms of A , v and V , to represent conservation of linear momentum for this decay.

.....
[1]

(ii) Show that the ratio

$$\frac{\text{initial kinetic energy of } \alpha \text{ - particle}}{\text{initial kinetic energy of daughter nucleus}}$$

is equal to $(\frac{1}{4}A - 1)$.

[2]

(c) Data for the α -decay of bismuth-212 ($^{212}_{83}\text{Bi}$) to form thallium-208 ($^{208}_{81}\text{Tl}$) are given in Fig. 9.2.

nucleus	mass of nucleus / u
bismuth-212	211.9459
thallium-208	207.9374
helium-4	4.0015

Fig. 9.2

(i) Use the data of Fig. 9.2 to calculate, to two places of decimals, the energy released during the decay.

energy = MeV [4]

(ii) Use your answer in (c)(i) to show that, based on the expression in (b)(ii), the energy of the α -particle is 6.42 MeV.

[2]

(d) In practice, the α -particle is found to have an energy of 6.10 MeV, rather than 6.42 MeV, as calculated in (c)(ii).

Suggest

(i) an explanation for the difference in energy,

.....
.....[1]

(ii) why it is likely that the thallium nucleus and the α -particle do not move off in opposite directions.

.....
.....
.....
.....[2]

(e) Some data for the half-lives and decay constants of bismuth-212 and thallium-208 are given in Fig. 9.3.

nucleus	half-life / s	decay constant / s ⁻¹
bismuth-212	1.9×10^{-4}
thallium-208	190	3.7×10^{-3}

Fig. 9.3

(i) Define *half-life*.

.....
 [1]

(ii) Complete Fig. 9.3 by calculating the half-life of bismuth-212.

[1]

(iii) Initially, a radioactive source contains N nuclei of bismuth-212.

After two hours, it is found that the number of bismuth-212 nuclei has reduced to approximately $\frac{1}{4} N$. However, although bismuth-212 decays to form thallium-208, the number of thallium nuclei is much less than $\frac{3}{4} N$.

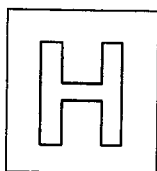
Suggest an explanation for these observations.

.....

 [4]

[Total: 20]

End of Paper



NANYANG JUNIOR COLLEGE
 JC 2 PRELIMINARY EXAMINATION
 Higher 2

CANDIDATE
 NAME

CLASS

TUTOR'S
 NAME

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INDEX
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PHYSICS

9749/04

Paper 4 Practical

15 August 2022

2 hours 30 minutes

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, class, tutor's name, Centre number and index number in the spaces at the top of this page. Write in dark blue or black pen on both sides of the paper. You may use a HB pencil for any diagrams, graphs or rough working. Do not use staples, paper clips, glue or correction fluid.

Answer all questions.

Write your answers in the spaces provided on the question paper. The use of an approved scientific calculator is expected, where appropriate. You may lose marks if you do not show your working or if you do not use appropriate units.

Give details on the practical shift and laboratory, where appropriate, in the boxes provided.

At the end of the examination, fasten all your work securely together. The number of marks is given in brackets [] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
Total	/ 55

This document consists of 17 printed pages.

- 1 Many electrical components have to function properly in conditions of extreme temperature and moisture content. In this experiment you will maintain a diode at 5 °C and investigate how the current in it varies as the potential difference across it is changed

(a) Set up the circuit shown in Fig. 1.1. The resistor R is to prevent current overload in the diode.

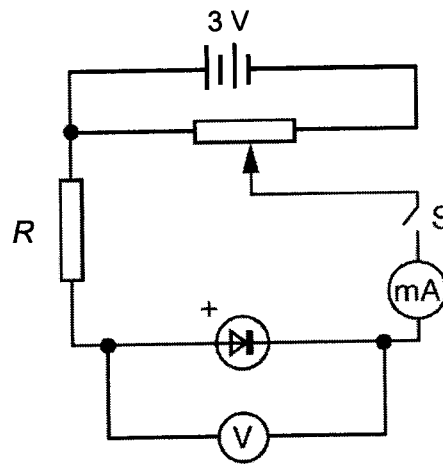


Fig. 1.1

(b) Put 50 ml of water into the beaker. Place the diode in the water.

Close Switch S .

Add a quantity of ice to the water in the beaker. Stir the ice/water mixture gently using the thermometer until the temperature is at, or close to, 5 °C.

- (i) Record the temperature of the ice/water mixture. You are to maintain this temperature to be within 2 °C of your recorded temperature for the rest of the experiment.

temperature of ice/water mixture = [1]

- (ii) Adjust the slider of the rheostat until the potential difference V across the diode is 0.70 V. Measure and record the current I .

I = [1]

- (c) Vary V and repeat (b)(ii).
Present your results clearly.

[6]

- (d) (i) The current I in the diode and potential difference V across it are related by the expression

$$I = I_0 e^{qV}$$

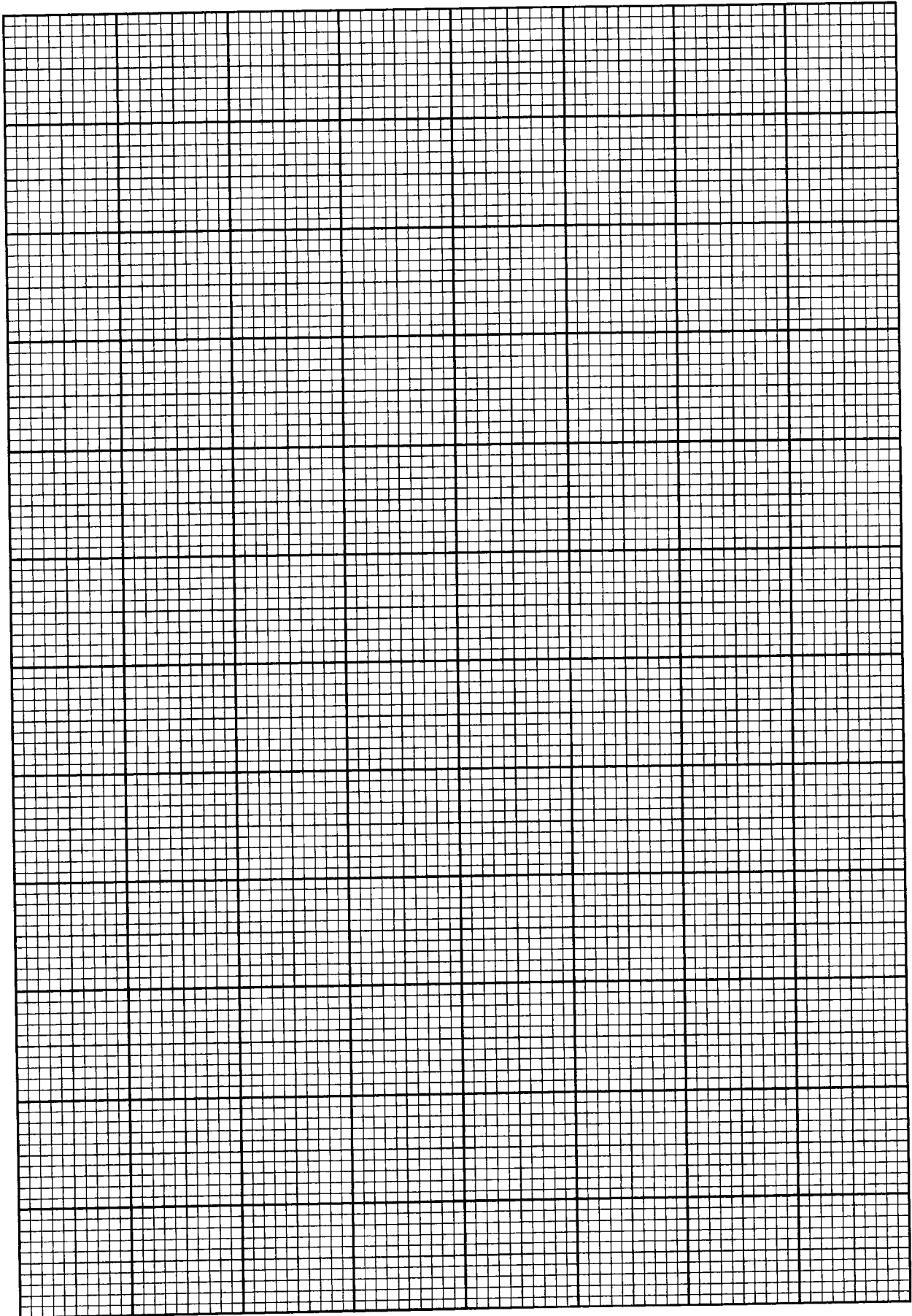
where q and I_0 are constants.

Plot a suitable graph to determine the values of q and I_0 .

$q =$

$I_0 =$

[5]



5

(d) (ii) Theory suggests that

$$q = \frac{a}{kT}$$

where k is the Boltzmann constant of $1.38 \times 10^{-23} \text{ J K}^{-1}$, a is a constant, T is the temperature of diode in kelvin where $T / \text{K} = T / ^\circ\text{C} + 273.15$.

Calculate a , giving an appropriate unit.

$$a = \dots\dots\dots [2]$$

(e) Calculate the current in the diode if it were placed in boiling water with a potential difference of 0.60 V applied across it.

$$I = \dots\dots\dots [1]$$

(f) The experiment is repeated where the value a is halved.

Sketch a line on your graph grid on page to show the expected result.

Label this line F.

[1]

2 In this experiment, you will investigate the oscillations of a pendulum.

(a) Set up the apparatus as shown in Fig. 2.1.

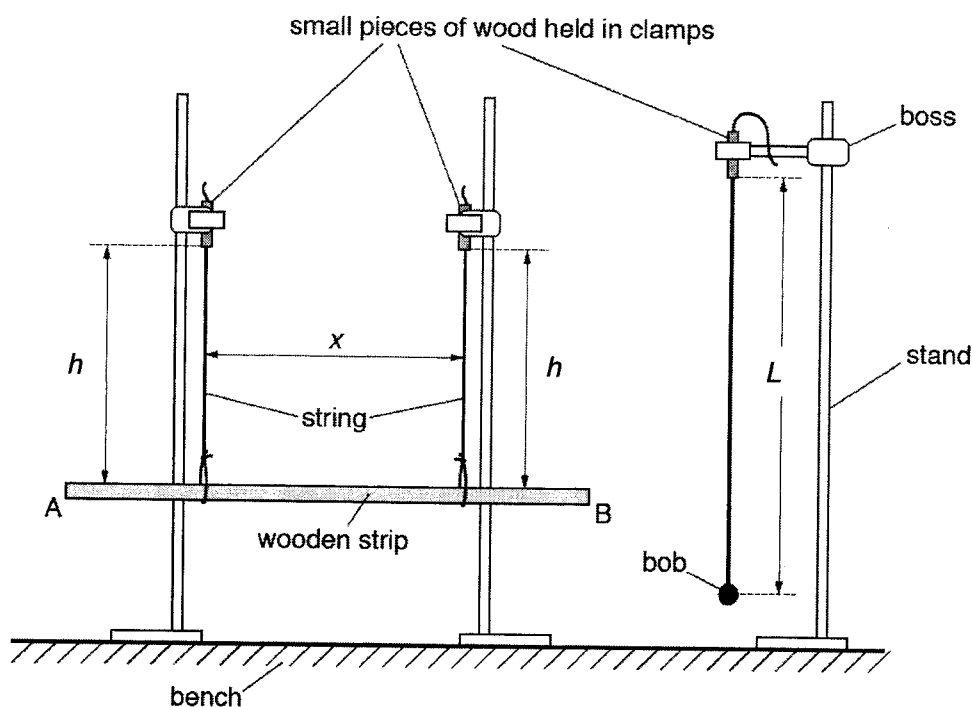


Fig. 2.1

The distance between the strings supporting the wooden strip is x .

The distances between the top of the strip and the bottom of the small pieces of wood should be equal. These distances are both h .

The distance between the centre of the bob and the bottom of the small pieces of wood is L .

Adjust the position of the strings so that $x \approx 25$ cm, $h \approx 25$ cm and $L \approx 45$ cm.

The strings should be vertical, the strip should be parallel to the bench and the strip should be supported centrally by the strings.

(i) Measure and record x and h .

$x =$

$h =$

[2]

(ii) Estimate the percentage uncertainty in your value of x .

percentage uncertainty = [1]

(b) (i) Pull the bob and end B of the strip towards you through a short distance.

Release the bob and the strip together so that they oscillate.

Adjust L until the periods of the oscillations of the bob and of the strip are the same.

Measure and record L .

$L = \dots\dots\dots [1]$

(ii) Estimate the percentage uncertainty in your value of L .

percentage uncertainty = $\dots\dots\dots [1]$

(iii) Calculate the value of Lx^2 with appropriate units.

$Lx^2 = \dots\dots\dots [1]$

(iv) Justify the number of significant figures that you have given for your value of Lx^2 .

.....
.....
..... [1]

- (c) Change x to approximately 30 cm while making sure h remains as the value stated in (a)(i).

The strings should be vertical, the strip should be parallel to the bench and the strip should be supported centrally by the strings.

Measure and record x .

$x =$

Repeat (b)(i) and (b)(iii).

$L =$

$Lx^2 =$

[2]

- (d) It is suggested that L is inversely proportional to x^2 .

Explain whether your results support the suggested relationship.

.....

 [2]

10

- (e) Using the available apparatus, investigate how a greater value of h affects the value of Lx^2 . Show your results and conclusion clearly.

.....

.....

.....

..... [3]

[Total: 14]

3 In this experiment, you will determine the weight of a metre rule.

(a) Attach the spring to the clamp. Suspend the mass hanger from the spring as shown in Fig. 3.1.

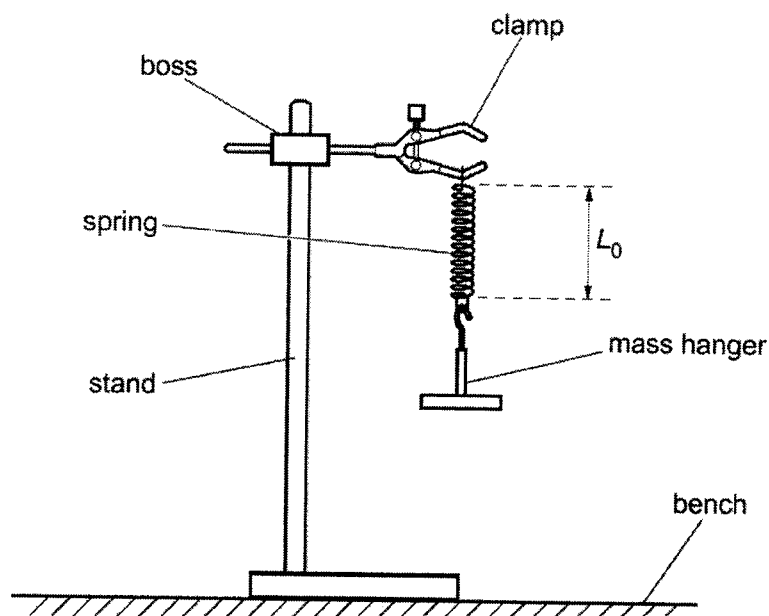


Fig. 3.1

The length of the coiled section of the spring is L_0 .
Measure and record L_0 .

$L_0 = \dots\dots\dots$

(b) (i) Add an additional mass of 100 g to the mass hanger. The new length of the coiled section of the spring is L_1 . Measure and record L_1 .

$L_1 = \dots\dots\dots$ [1]

(ii) Remove the 100 g mass.

(iii) The spring constant k is given by the equation

$$k = \frac{F}{(L_1 - L_0)}$$

where F is 0.981 N.
Calculate k .

$k = \dots\dots\dots$ [1]

(c) (i) Set up the apparatus as shown in Fig. 3.2.

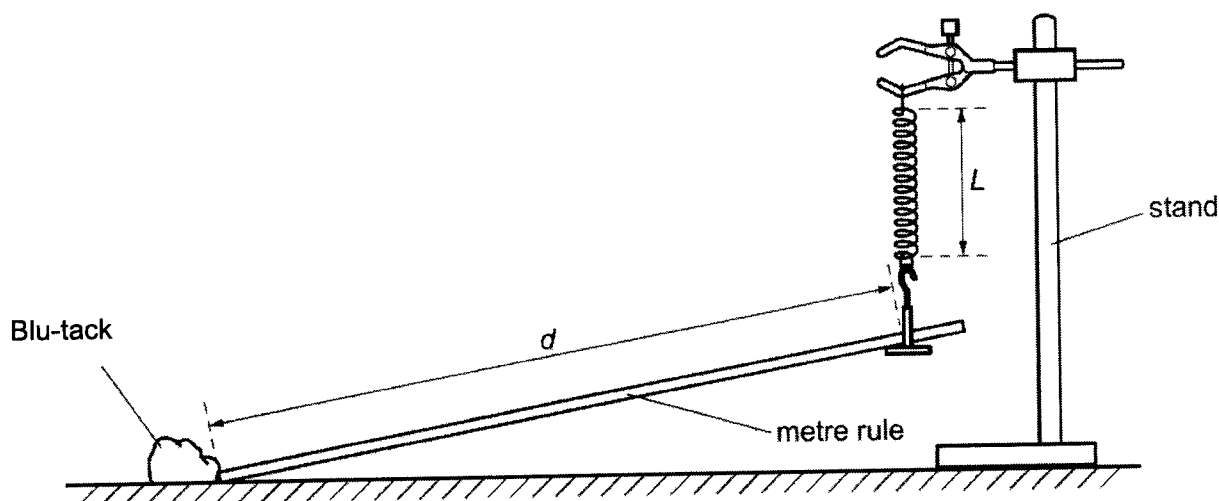


Fig. 3.2

Support the rule on the mass hanger. You may need to use some of the blu-tack to stop the rule from slipping off the mass hanger.

The distance between the lower end of the rule and the mass hanger is d , as shown in Fig. 3.2. The length of the coiled section of the spring is L .

Adjust the apparatus so that d is approximately 90 cm and the spring is vertical.

(ii) Measure and record d and L .

$d =$

$L =$

(iii) Using your answer to (a), calculate $(L - L_0)$.

$(L - L_0) =$ [1]

(iv) Repeat (c)(ii) and (c)(iii) with a distance d of approximately 60 cm.

$d =$

$L =$

$(L - L_0) =$

[2]

13

- (d) It is suggested that the relationship between $(L - L_0)$ and d is

$$C = d(L - L_0)$$

where C is a constant.

Use your values from (c) to determine two values of C .

first value of $C = \dots\dots\dots$

second value of $C = \dots\dots\dots$

[1]

- (e) The constant C is given by

$$C = \frac{Wd_0}{2k}$$

where d_0 is the length and W is the weight of the metre rule.

Use your second value of C to determine W .

$W = \dots\dots\dots$ [1]

- (f) If you were to repeat this experiment with different distances d , describe the graph you will plot to determine W .

.....

 [1]

[Total: 8 marks]

- 4 When an elastic cord of circular cross-section is stretched between two points A and B and is made to vibrate, stationary waves can be set up on the cord. A possible shape (mode of vibration) for the stationary waves is shown in Fig. 4.1.

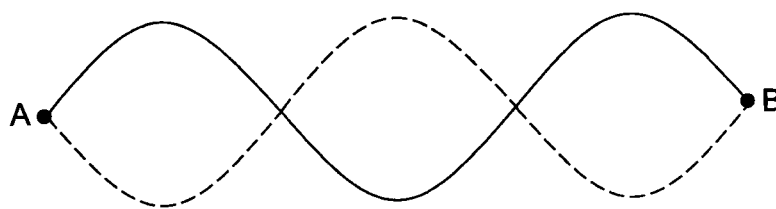


Fig. 4.1

The frequency of vibration of the elastic cord in this mode of vibration depends on the tension in the cord and the mass per unit length of the cord.

It is suggested that the relation between the frequency f of this mode of vibration of the cord, tension T in the cord and mass per unit length μ of the cord is

$$f = kT^p \mu^q$$

where k , p and q are constants.

Design an experiment to determine the values of k , p and q .

You are provided with cords of different thickness. You may also use any of the other equipment usually found in a physics laboratory.

Draw a diagram to show the arrangement of your apparatus. You should play particular attention to:

- the equipment you would use
- the procedure to be followed,
- the method by which the mass per unit length μ of the cord is determined,
- the control of variables,
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

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